Citizen-led initiatives in the German wind energy sector

- a qualitative and quantitative exploration

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Master Thesis in Climate Change Management

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Master thesis in Climate Change Management

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Abstract

Onshore wind energy development in Germany faces a problem, the citizens do not want wind turbines in their backyard (NIMBY). Citizen-led initiatives, prominently in form of energy cooperatives, are deemed to increase the acceptance for wind energy production in close proximity. They provide the opportunity for (local) citizens to financially benefit from and democratically take part in the planning process of wind power production.

This thesis provides a combination of statistical analysis of the COMETS database and qualitative review of wind energy cooperatives. The findings are combined in a stylized business business model canvas for cooperatives in the wind energy sector. Two case studies deliver in depth investigations of the currently biggest wind energy cooperative, PROKON regenerative Energien eG, in Germany and a classical mid-sized wind cooperative, Energiegenossenschaft Starkenburg eG.

The master thesis found 137 active wind cooperatives with 597 associated projects (1.9 GW) in Germany. Cooperative activity in the wind sector is strongly dependent on favourable political support schemes, providing low complexity and relatively risk free investment opportunities (e.g., guaranteed feed-in tariffs). Furthermore, wind cooperative headquarters are predominantly found in southern Germany, whereas the wind projects are equally spread across the country. This finding contrasts the idea of wind power production in the backyard, indicating that southern German cooperatives finance and profit from northern wind turbines. The case studies exemplify diversification and growth strategies as solutions to cope with increasing competition on the market due to tendering. Both strategies are promising solutions for future citizen-led activity in the wind energy sector.

I Tyskland står vindenergiutviklingen på land ovenfor et problem, innbyggerne vil ikke ha vindturbiner i bakgården (NIMBY). Innbyggerledende tiltak, fremtredende i form av energikooperativer, anses å øke aksepten for vindkraftproduksjon i umiddelbar nærhet. Dette gir muligheten for (lokale) borgere å dra nytte av og demokratisk delta i planleggingsprosessen for vindkraftproduksjon.

Denne oppgaven gir en kombinasjon av statistiske analyser av COMETS-databasen og en kvalitativ gjennomgang av vindkraftkooperativer. Funnene er kombinert i en stilisert business model for andelslag i vindenergisektoren. To casestudier gir grundige undersøkelser av PROKON regenerative Energien eG, vindkooperativet som er for tiden størst i Tyskland, og Energiegenossenschaft Starkenburg eG, et klassisk mellomstort vindkooperativ.

Masteroppgaven fant 137 aktive vindkooperativer med 597 tilknyttede prosjekter (1,9 GW) i Tyskland. Samarbeidsaktivitet i vindsektoren er sterkt avhengig av gunstige politiske støtteordninger, som gir lav kompleksitet og relativt risikofrie investeringsmuligheter (f.eks. Garanterte innmatingstariffer). Videre er hovedkvarteret til vindsamarbeid hovedsakelig funnet i Sør-Tyskland, mens vindprosjektene er spredt over hele landet. Dette funnet står i motsetning til ideen om vindkraftproduksjon i bakgården, noe som indikerer at sørtyske kooperativer finansierer og tjener på nordlige vindturbiner. Casestudiene eksemplifiserer diversifiserings- og vekststrategier som løsninger for å takle økende konkurranse på markedet på grunn av anbud. Begge strategiene er lovende løsninger for fremtidig borgerledet aktivitet i vindenergisektoren.

Contents

List of Figures

List of Tables

Abbreviations

BM: Business model
BMC: Business model canvas
CCS: Carbon capture and storage
CHP: Combined heat and power
EU: European Union
EUR: Euro
GHG: Greenhouse gas
kW: Kilo watts ($10^3 W$), to measure capacity of wind turbine
kWh: Kilo watt hours ($10^3 Wh$), to measure produced electricity
LCOE: Levelized costs of electricity
MW: Mega watts ($10^6 W$), to measure capacity of wind turbine
NIMBY: Not-in-my-backyard
PV: Photo-voltaic
RE: Renewable energy
USD: United States Dollar

Chapter 1

Introduction

In 2019, the German economic newspaper Handelsblatt headlined: "The problem with wind energy is that it experiences increasing opposition by people living in close proximity to planned sites for wind turbines - the conflict often even ends up in court. This clearly interferes with the wind energy development goal". The article outlines a lack of involvement of local citizens in the planning process of new wind turbines as one of the main reasons for their opposition. Missing involvement in the early stages of wind development has been stated to be the cause for a general acceptance problem of wind energy production in particular when placed nearby, which is also known as the not-in-my-backyard (NIMBY) attitude (c.f. Sack, 2018).

The apparent solution to resolve the outlined problem is to involve citizens in general, and especially the ones directly affected, into the process of wind energy projects. One way to involve local citizens is shareholding. Through their economic investment, they tend to identify themselves with and profit from the local production facilities. The accrued benefits are referred to as local value proposition (Ohlhorst, 2018). Participation beyond mere economic investment is also possible, when citizens take on leadership in projects, and thus are able to actively steer local energy developments. This form of citizen engagement is often organized by means of an initiative or a project. Citizen-led initiatives are deemed to have a positive influence on the acceptance of renewable energy projects in the local community (Lowitzsch, 2019). Furthermore, they create the opportunity to support market resilience by providing a diversification of the energy market actor landscape (Ohlhorst, 2018). In addition, citizen-led initiatives have the ability to invest, where market conditions are not economically feasible or attractive for corporate investors. Thus, citizen-led initiatives create the opportunity to prevent market failures with respect to the distribution of renewable energy technologies in the decentralized energy transformation process in Germany. Consequently, citizen initiatives are an important driver of efficient renewable energy development in Germany (Wierling et al., 2018).

In addition to their importance in transforming the landscape of the energy market, citizen-led initiatives drive innovation. An example of a successful, innovative citizen project is called "Dörpsmobil". The founders of the project combined the need for a car sharing solution in the rural area with a local wind power project. Their electric car-sharing vehicles are charged with locally produced electricity and thus, this model contributes to efficiency through sector coupling (UBA, 2021a). Furthermore, sector coupling leads to increasing energy market resilience (UBA, 2021a).

Even though this thesis focuses on Germany, the importance of citizen engagement is not only recognized on the national level, but also on the supranational level of the EU. This reflects for example in the recent Directive EU-2019/944, which aims at strengthening the position of citizen-led initiatives in the European energy market.

This thesis investigates citizen-led contribution in the German energy transition, with a focus on the wind energy sector. The goal is to answer what citizen-led initiatives currently contribute to the energy transition and what enables or hinders their activity on the energy market.

In the attempt to reach the national target of 100% carbon neutral electricity production and consumption by 2050, electricity from solar photo-voltaic and onshore wind turbines play a crucial role (UBA, 2021b). The latter provides the majority of the German electricity production already today with 18.7% (BMWi, 2021a) and has a long tradition in Germany. The history dates back to the early 1900s, when pioneers explored the use of wind as an energy resource and paved the way for German wind turbine manufacturers today.

In order to bring together wind energy demand and citizen engagement in the energy transition process, potential initiatives are in need of a legal structure to engage in the energy market. A suitable framework for citizen engagements is provided by the cooperative structure (Gregg et al., 2020). According to the international cooperative association (ICA, 2017), a cooperative is defined as an entity based on democratic principles. A cooperative serves its members to fulfill social, cultural and economical needs. Its legal form represents a formally recognized entity and has a longstanding tradition in the energy sector, dating back as far as the 19th century (Punt et al., 2021). Today, the cooperative landscape is diversified and one of its more recognised examples is the energy cooperative. Among the various concepts of citizen initiatives, energy cooperatives provide a well defined form in the energy sector (Gregg et al., 2020) and are therefore a suitable framework to study citizen-led initiatives. At the general assembly of the cooperative, their members hold democratic votings on matters of the cooperative, manifesting the leadership of their members. For example, they elect their future management personal or have a voting on future business models. This mutual, democratic characteristic of cooperatives paired with a well developed legal position create a suitable vehicle for citizen-led initiatives.

Recently, social innovation of citizen-led initiatives drew the attention of the research community. The interest has been sparked because such initiatives go beyond the mere technical energy transition of renewable energies. They additionally generate societal benefits including, but not limited to, increased citizen participation, public acceptance, and energy awareness (Lowitzsch, 2019). However, it still remains unclear on an aggregated level to what extent citizen initiatives are contributing to energy transitions (Wierling et al., 2018). Combining this question and the importance of the wind energy sector for the German energy transition, this study aims to gain an understanding of the role of citizen-led initiatives in the wind energy sector answering the following (research) questions:

- What qualitative and quantitative statements can be made about the current state of citizen-led projects in the German wind energy sector?
- What are the prospects for citizen-led initiatives in the wind sector? What barriers and enablers do exist?

Focusing on cooperatives as a major citizen-led actor in the German wind energy sector, the master thesis contributes to the COMETS database and conducts a statistical analysis for wind energy cooperatives in Germany. The COMETS project is a European research program dealing with collective action in energy transformations and social innovation. In addition, a systematic review of cooperative websites provides qualitative data, complementing the quantitative exploration. Furthermore, by applying a business model canvas, both types of data are combined, and the master thesis examines the current status of cooperative activity in the wind energy sector. Moreover, two case studies are investigated. The first case study focuses on PROKON regenerative Energien eG, which is currently the biggest wind energy cooperative in Germany owning about 287 projects nationally. PROKON regenerative Energien eG is an interesting case as it initially started out as a corporation in the 1990s, changing to the cooperative legal form after insolvency. The second case, Energiegenossenschaft Starkenburg eG, can be considered a classical medium sized cooperative, managing seven regional wind projects. It is a prime example of how citizens can profit from the local wind power production. The two case studies also show an interesting twofold geographical contrast. Firstly, PROKON regenerative Energien eG was founded in northern Germany, whereas Energiegenossenschaft Starkenburg eG in a southern federal state. Secondly, Energiegenossenschaft Starkenburg eG is regionally active, whereas PROKON regenerative Energien eG also operates wind parks in other EU countries.

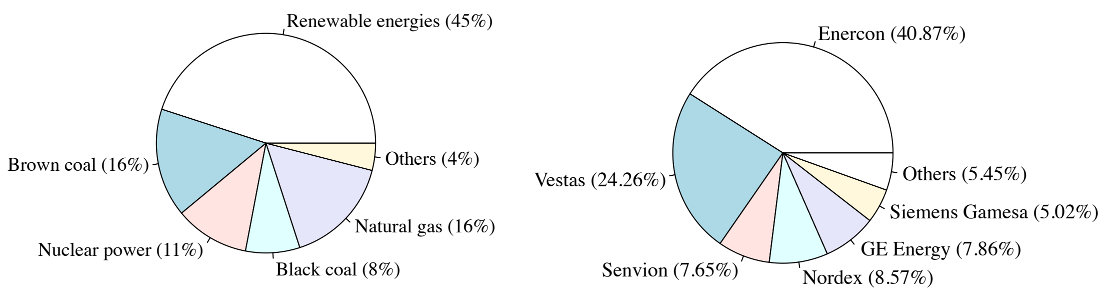
This master thesis is structured in the following way: first, the current trends in the German wind energy sector are described (Chapter 2). In this chapter, the technological development of the sector is examined, as well as the energy market actor landscape, and associated legal frameworks. In Chapter 3, information on the data compilation, numerical and qualitative analysis methods is provided. Chapter 4 presents the results, namely, the statistical insights of citizen engagement in the wind energy sector, a comparison with other market actors, business models identified and the two case studies. The fifth Chapter summarises the current state of citizen initiatives, barriers and enablers, and presents prospects for the future. The last chapter concludes, points out limitations and provides an outlook for future research in the area (Chapter 6). The main finding of this master thesis is the strong cooperative dependence on political support schemes in the German wind energy sector, identifying unfavourable political support schemes (e.g., tendering) as barriers for citizen-led initiatives.

Chapter 2

The German wind energy sector

2.1 Trends in the German wind energy sector

In Germany onshore wind power production 2020 accounted for 18% of the gross electricity production in 2020 and is therefore the single biggest contributor by technology (BMWi, 2021a) (see Fig. 2.1(a)). However, this share has to be viewed cautiously due to a visible effect of the COVID-19 pandemic on the total electricity consumption in Germany. The total amount of onshore capacity accounted for 54.4 GW in 2020 (BMWi, 2021b). After the record year 2017, in terms of newly installed onshore capacities, the build up of new capacities in 2020 was at a very low level (UBA, 2021c). The 2017 change of the Renewable Energy Sources Act introduced a market-based support scheme, called tendering. This led to a decrease in installed onshore wind power in last two years, and most of the tender volumes were not exhausted by bids received (Bundesnetzagentur, 2021a).



(a) Gross electricity production (2020). (b) Market shares of producers in Germany (2018).

Figure 2.1: German gross electricity production in 2020 (BMWi, 2021a) and market shares by wind turbine producers in Germany adopted from Fraunhofer IEE (2018).

The current market for wind turbines in Germany is dominated by the German manufacturer Enercon GmbH and the Danish Vestas Wind Systems A/S company (Fig. 2.1(b)). Other international competition from the American GE Energy plays a minor role on the market.

The energy transition process in Germany, widely known as ”Energiewende”, has its origin before the 1990s. During that time, Germany was strongly dependent on fossil fuel imports from other countries to satisfy its energy demand. To become more independent from international energy trade, German politicians decided to steer the energy sector towards nuclear and renewable power supply. The Chernobyl nuclear disaster (1986) and, later, the Fukushima Daiichi accident (2011) are two important historic breaks, leading to the decision of a nuclear phase-out in Germany.

In the year 1991, the Electricity Feed-in Law was introduced as the first legislative framework guaranteeing the feed-in of renewable electricity into the electricity grid. Later it was followed by the Renewable Energy Sources Acts continuing the support for onshore wind production.

The development in Germany coincides with the liberation of the European electricity market in 1998 (Holstenkamp and Radtke, 2018b). This provided the basis for multinational electricity trade. Until then the market was under control of the "big four utilities", being effectively an oligopoly, before opening up for other market actors, like cooperatives (Sack, 2018). The two major changes, namely feed-in guarantees and the liberalization of the European electricity market, are considered the most important factors for the spread of onshore wind power generation (c.f. Reiche and Bechberger, 2004; Silva and Klagge, 2012).

2.1.1 Market development

The German wind energy market has a history dating back about 50 years. Schematically, the market allows citizen-led initiatives and private corporations to either compete or cooperate. Their courses of action are hereby restricted by policies.

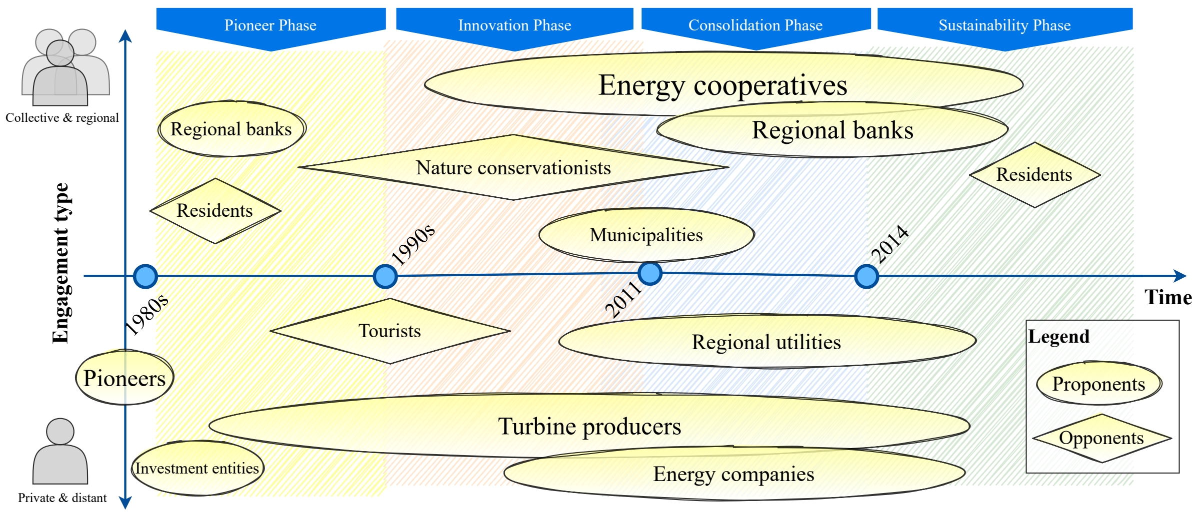


Figure 2.2: Phases of wind energy development in Germany, displaying main opponents and proponents. Own revision, based on Bauriedl (2016) and Walker and Devine-Wright (2008).

Figure 2.2 illustrates the chronological market development, divided into four major market development phases and shows the main proponents and opponents of the wind power market. The market actors are sorted on a scale according to their engagement type, ranging from private and distant to collective and regional.

Prime examples for a private and distant actor are investment entities, which do not need spatial and community connection to the wind projects they are funding. At the other end of the spectrum are the energy cooperatives. They are drivers of community engagement, typically drawing from strong local ties. This also includes regional banks partly as they may be organized in cooperative structures. As such, they are well situated within the collective engagement. Nature conservationists and residents opposing wind power plants in their neighbourhoods are usually organised in associations, which also represent a form of collective action (c.f. Section 2.1.3). Turbine producers, energy companies, and regional utilities are usually private (legal) entities, which act as standard enterprises on the market and are not necessarily locally tied.

The wind energy market in Germany has its roots in the individual efforts of wind energy pioneers before the 1980s. These pioneers were intrinsically motivated to build small onshore wind turbines on their own properties to gain independence from the centralized power grid infrastructure. These initial efforts paved the way for the gradual development of the German wind energy market. As previously stated, the market development can be clustered into four major market development phases from the 1980s onwards. The first development phase is termed „pioneer phase“ by Bauriedl (2016). It roughly spans the period from early 1980s until the early 1990s and is characterized by the transition from initial private pioneers' efforts to the development of a niche market and the establishment of small companies (Bauriedl, 2016). Between 1980 and 1990, only large scale wind power plants benefited from political support schemes. The „pioneer phase“ was followed by the „innovation phase“ (Bauriedl, 2016). In this market development phase, beginning in the early 1990s, the founded turbine manufacturers gradually grew into small and medium sized companies and were able to develop larger turbines. New actors, like municipalities, regional utilities, and energy cooperatives also gradually joined the market (Bauriedl, 2016), which can at least in part be attributed to the newly introduced Electricity Feed-in Law in 1991.

Technical and market maturity continued to grow steadily with complementary policy developments after 2000, which also affected markets beyond the German borders. This effect manifested itself in the introduction of new environmental and technology policies in several countries (Silva and Klagge, 2012). Political support schemes throughout Europe, comparable to the German Renewable Energy Sources Act, increased the demand for wind turbines internationally. Until 2006, the export quotas of the German wind energy industry, including manufacturers and sub-contractors, rose to around 74% of the total turnover (DEWI GmbH, 2006). As a consequence, some turbine producers entered the stock market to acquire more capital (e.g., Nordex SE TecDAX listing 2006). With the European financial crisis starting in 2009, a development dip in the wind energy industry occurred (Silva and Klagge, 2012), which resulted in relocations of production facilities to Asia due to comparative cost advantages.

The aftermath of the Fukushima Daiichi accident (2011) induced a strong political paradigm shift, leading to the declaration of nuclear phase-out in Germany and the prioritization of renewable energy production. This event can be considered the starting point of the "consolidation phase" . The market actor landscape solidified under the political security of guaranteed feed-in tariffs by the Renewable Energy Sources Act. With the 2014 amendment of the Renewable Energy Sources Act, including the introduction of a market-based approach to state support, the „consolidation phase“ was superseded by the so-called „stability phase“ (see Fig. 2.2). The amendment limits the amount of state support and the application of command-and-control policies. From now on wind energy actors have to prove their commercial viability under market conditions.

Considering the importance of global markets for today’s trade, the development has to be viewed in a global context. Beside the German production, the earlier phases of the German market development were dominated by the Danish competitor Vestas Wind Systems A/S. A minor role on the German wind market played the former Spanish competitor Siemens Gamesa Renewable Energy S.A. and the American GE Energy. In the late 2000s, Asian manufacturers entered the market with competitive technologies matured on their respective national markets. One example is the Chinese manufacturer Xinjiang Goldwind Science & Technology Co. Ltd., which ranks today among the top five wind producers in the world (Haqqi, 2020). Despite strong competition from outside Germany, today’s producer landscape in Germany is dominated by the national producer Enercon GmbH, with Danish company Vestas Wind Systems A/S as its strongest competitor (see Fig. 2.1(b)).

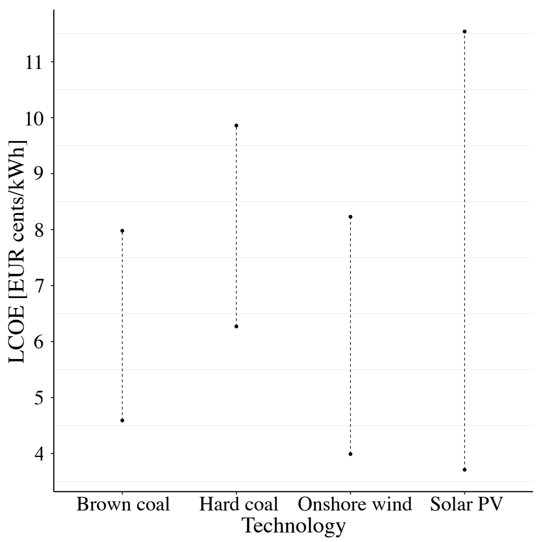


Figure 2.3: Levelized costs of electricity production by energy technology in Germany (2018), own figure based on Fraunhofer ISE (2018).

Over the last decades, technological innovation and development led to a larger size and capacity of wind turbines. Cost reductions resulted not only from technological innovations, but also from economies of scales and learning curves in the wind energy industry. This overall development resulted in a decrease of the costs associated with the production of one kWh (IRENA, 2020). The global levelized costs for electricity production from onshore wind declined from 8.6 USD cents/kWh in 2010 to 5.3 USD cents/kWh in 2019 (IRENA, 2020). Lundberg (2019) predicts that the trend of declining costs for wind energy is likely to continue in the future. On the national level of Germany Fraunhofer ISE (2018) describe a range of 3.99 to 8.23 EUR cents/kWh for onshore wind power production. These costs allow producers to compete with conventional, fossil fuel based power plants (e.g., brown coal, hard coal). Fig. 2.3 shows the ranges of LCOE for the renewable power plants utilizing solar PV or onshore wind in comparison to coal electricity production. Both renewable energy technologies depend heavily on location and size of power plant, thus having a broad range. However, in the context of citizen-led projects it is important to keep in mind that the overall investment volumes for wind projects rose, despite the decrease in production costs.

Today, the technical advancements allow profitable operation of wind power plants already in medium and low wind zones. This leads to discussions about wind projects across Germany (Bauriedl, 2016). Despite living in regions with generally lower wind yield potential, citizens in the southern regions of Germany are now confronted with potential onshore wind power projects in their backyard. This creates a vital debate throughout the country, discussing the conditions for acceptance of wind power production.

2.1.2 Technical development

The market development was and still is significantly influenced by technological advancements, impacting the compartment prices, efficiency and safety of power plants, among others. Technological innovation can also alter the burden imposed on nature and people, for example by reducing noise emissions from wind turbines. By reducing adverse effects on nature and people, acceptance hurdles may be removed and a broader acceptance is achieved. Technological advancements can on the other hand also lead to an increase in complexity, which creates a barrier for non-professionals to enter the market. This might be the case for cooperatives in particular, since their work is mainly based on voluntary work from their members, who may not have expert knowledge or are restricted regarding the time they are able to invest (c.f. Herbes et al., 2017), and thus might not be able to keep up with the increasing complexity. In comparison to other renewable energy technologies utilized by cooperatives, wind power plants are regarded as technologically mature (Silva and Klagge, 2018). In general, there are two types of turbine configurations. The axis of the rotor can either be vertical or horizontal. The former is used for example as small scale wind power plants on roofs. As Konstantinidis and Botsaris (2016) point out, the latter is more efficient and therefore the most common one. As a rule of thumb, the bigger the rotor, the more efficient is the power production. This reflects in the doubling of rotor sizes within one decade until 2016 (Konstantinidis and Botsaris, 2016). Silva and Klagge (2012) find a similar trend for the early years of wind power production between 1980 and 2010, where rotor diameters increases from 15m to 127m.

In regard to the topic of the master thesis, the technology applied by the majority of citizen-led onshore wind power productions are horizontal axis wind turbines. These wind turbines consist of the following main components: a foundation, an anchor component, controller units and other electronics, cables, a turbine transformer, a tower, blades and hub (rotor system), and the nacelle (see Fig. 2.4). The nacelle houses a generator, a gearbox, other electrical parts, and is

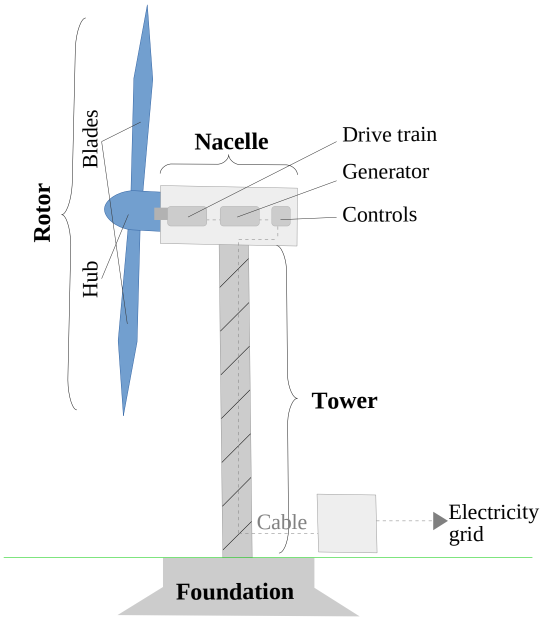


Figure 2.4: Schematic drawing of wind turbine components, own drawing.

protected by the nacelle-cover and foundation. Table 2.1 depicts a Vestas Wind Systems A/S V112-3.45 MW turbine and breaks down the general material composition of a wind turbine. Table 2.1 shows also that the manufacturing costs of wind turbines are in particular dependent on steel prices (Hau, 2013, p. 804).

The overall costs of a wind power plant can be divided into two categories: the costs of building the turbine and grid connection, and the costs for maintenance and operation. All costs are location- and system-specific. Therefore, only an exemplary cost break down is presented in Table 2.2. In addition to the building costs, maintenance and operation costs account for an average of 25% of the total costs of a wind turbine (Strack et al., 2021). The maintenance costs increase constantly over the lifetime of a wind turbine due to wear. Staffell and Green (2014) found that the costs of power production increase by 9% within a 20-year-lifespan

Material in [t], if not indicated otherwise	Turbine	Foundation	On-site infrastructure
Steel and Iron materials	382	90	1
Aluminium including alloys	4	0	6
Copper (and alloy)	3	<1	2
Polymer materials	17	<1	11
Process polymers (e.g. sealant)	1	0	0
Ceramic / glass	26	0	<1
Concrete	0	1395	0
SF6 Gas in [kg]	8	0	1
Magnets	<1	0	0
Electronics / electrics (total)	3	0	0
Lubricants and liquids (total)	2	0	<1

Table 2.1: Material breakdown of one Vestas Wind Systems A/S V112 wind turbine modified after Vestas Wind Systems A/S (2017). Category on-site infrastructure includes cables, switch gears and transformer needed for grid connection.

of a wind turbine. This can be jointly attributed to increasing maintenance costs and a decline of power output by 12% over 20 years (Staffell and Green, 2014), caused by wear and tear. The increasing costs for wind turbine operation pressure operators economically, the longer the turbine is operated. To counteract

Component	Cost [US$] (2014)	Proportion of total cost [%]
Rotor	486,200	29
Mechanical drive train and nacelle	524,000	32
Electrical system	255,000	16
Tower	390,000	24
Sum of component cost	1,637,200	100
Expected sales price (including overhead surcharge)	2,455,800	150

Table 2.2: Cost structure of a geared 2 MW onshore wind turbine with a 80 m tower, modified from Hau (2013, p. 806).

such economic strains, Strack et al. (2021) report potential for a further reduction of overall costs of onshore wind turbines in the future, if a more systematic approach, termed condition-oriented maintenance, is chosen. This approach demands an extensive, machine-based monitoring and analysis system.

After a 20-years-lifespan with state remuneration, wind turbines usually have to be either dismantled or re-powered to become economical profitable again. Re-powering describes a process, where old wind turbines are replaced by newer generation models on the same site. This process increases economic efficiency and installed capacity. The possibility of re-powering depends highly on regional zoning plans. If the old turbine is not placed within the boundaries of the currently valid wind development zones, it is unlikely that re-powering is possible for the specific site (UBA, 2019b). In the years 2020 and 2021, the 20 year state support ends for a large amount of wind turbines, posing the question whether they should be dismantled or re-powered (UBA, 2019b).

Currently, onshore wind turbines from German and international manufacturers have capacities ranging mainly between 2 and 6 MW (Tab. 2.3). Beside the big European companies Vestas Wind Systems A/S and Enercon GmbH, who dominate the German market, Xinjiang Goldwind Science & Technology Co. Ltd. was added to exemplary represent the international competition faced from Asia.

In addition to building fewer wind turbines with the same capacity, technical measures can be applied to reduce the environmental impacts (UBA, 2019a). This category of impacts includes noise emissions, shadowing, light emissions (aviation

Company	Country of origin	Available turbine size
Vestas Wind Systems A/S	Denmark	2.0 - 6.0 MW
Nordex SE	Germany	3.6 - 5.5 MW
ENERCON GmbH	Germany	0.8 - 5.5 MW
Xinjiang Goldwind Science & Technology Co. Ltd.	China	2.0 - 6.X MW

Table 2.3: Wind turbine sizes from producers present in the dataset and the biggest Asian company as a comparison. Sourced from official websites.

obstruction markers and stroboscope effect from rotor), ice throw and danger for birds and bats. Technical measures are either special coating or colouring of the wind turbine parts (e.g., anti ice coating), automatic detection and shut-/slow-down mechanisms (e.g., bird detection, shadow detection), or aerodynamic shape adjustments (e.g., noise reduction ends for rotors). Turbine producers and/or operators are already obliged by regulations to apply for example anti-ice coating on the rotors. The communication of applied measures within a project to citizens in close proximity to the wind energy plants can have positive effects on the citizens' acceptance of local wind power facilities. Nonetheless, UBA (2019a) notes that this will only be a minor part of the solution to increase societal acceptance of onshore wind power. Despite the positive effects associated with the presented technical measures, they also increase the complexity for citizen-led wind power projects. Thus, the abundance of measures may create obscurity in the planning and investment process for non-professional citizen-led energy projects.

2.1.3 Actor landscape

Citizen-led initiatives in the energy market can take a number of different legal forms, serving specific aims. For an extensive description of the German citizen actor landscape see Holstenkamp and Radtke (2018a). A summary of relevant forms in the context of this thesis is presented in Tab. 2.4, also showing an overview of the different laws connected to the legal forms and obligations associated with them. In this thesis I distinguish between cooperatives, associations, limited liability companies (GmbH), limited companies (KG), partnerships under the German civil code (GbR), and foundations.

Gregg et al. (2020) state that cooperatives are well-defined legally and thus can be considered a suitable form to support citizen initiatives on the energy market. Another similar, but less confined legal structure for engagement in Germany is the association. Typically, this legal form is based on some sort of informative missions, either supporting or opposing onshore wind power. Holstenkamp and Kahla (2016) also add categorise the limited liability legal forms as the most dominant ones next to cooperatives in regard to citizen renewable energy production. The authors especially emphasize their importance in the wind energy market, where several forms of limited entities can be found. In case of a suitable underlying shareholding structure, they can also be classified as citizen-led. A typical example is a cooperative holding 100% of shares of a limited liability company operating a wind turbine. Foundations generally only play a minor role for citizen engagement in the wind energy market. As wind projects often involve several partners with different backgrounds, a network structure of several legal forms is common.

Cooperatives have a history of more than 150 years in Germany (Klagge and Meister, 2018), originally established in order to create a security net for local farmers via agricultural cooperatives. Thereafter, energy cooperatives emerged and supported electrification in rural areas. Later, the electrification purpose was expanded to renewable energy production as well as other diverse activities, including heat contracting and energy efficiency consulting. Next to existing cooperatives extending their portfolio, new ones were founded with a distinct purpose of operating or financing of renewable energy projects. A typical example for a medium-sized renewable energy cooperative is Energiegenossenschaft Starkenburg eG, further described in Section 4.3. They, for example, benefit the local community by providing transparent electricity tariffs, which partly explains why energy cooperatives are viewed positively by society (DGRV, 2019).

Cooperative businesses represent a special case, because of their hybrid function. On the one hand they have a strong economic focus, on the other hand they also act as a civil or social actor (Ohlhorst, 2016). The legal form of a cooperative is internationally defined as an association, where members join voluntarily to meet shared economical, social or cultural needs in a democratically ruled enterprise (ICA, 2017). Under the cooperative principles of self-help, self-responsibility, democracy, equality, equity, and solidarity, cooperative action is defined. These principles usually translate into a one-member-one-vote principle, discarding the amount of shares the member is holding in decision processes. The general assembly is the organ, which ensures and enacts the democratic voting procedures. Consequently, the cooperative members have a major role in cooperative's business models (see Chapter 3). If initiatives like to promote the participation of members, the cooperative form is often chosen as a legal vehicle.

German cooperatives are organised in the superordinate registered association "Deutscher Genossenschafts- und Raiffeisenverband e.V" (DGRV). The main task of the DGRV is to support cooperatives in Germany, which includes lobbying for the cooperative idea and legal structure in the political system, creating a network for cooperatives and supervising the cooperative inspection procedures. Direct members of the DGRV are cooperative associations, which for their part split into regional or sector-specific associations. The sectors include, but are not limited to, cooperative banking, goods and services, cooperative stores, and energy production and services.

All cooperative action is tied to regulations found in the cooperative law (GenG). The GenG states that cooperatives are (solely) bound to their purpose and the benefit of their members. To ensure the legitimate status of cooperatives they are members of and regularly controlled by an inspection association ("Prüfverband"). The management of cooperatives (and depending on the size also the supervisory board) are elected at the yearly general assembly.

The democratic structure and the simultaneous aspiration of economic and social goals also affect the risk behaviour of the cooperatives. As frequently mentioned in the literature, one characteristic of cooperatives is risk aversion (Herbes et al., 2017) or generally a more conservative approach to risks.

The member composition structure has a major influence on cooperative behaviour as well. The average member is male, between 40 and 60 years old, and receives an above average income (Drewing and Glanz, 2020; Klagge and Meister, 2018). As most cooperatives evolve from bottom-up initiatives of citizens, a local anchorage is common. This rooting is crucial for the early success of a newly founded cooperative, but might also turn into a barrier for expansion in a later stage (Punt et al., 2021). Locally bound cooperatives might struggle with a lack of suitable wind development sites within their regional boundaries or a shortage of members necessary to acquire the amount of investment capital needed for expansion. Regional solidarity facilitates connections between cooperatives and to regional banks, which play an important role in the financing process of citizen energy projects (Nolden, 2013).

These regional banks are often times also organised as cooperatives. First and foremost, energy cooperatives draw from the competencies of their founders and members, which form the base for their activities (DGRV, 2019).

Voluntary engagement by members is essential for the functioning of the cooperative, especially with regard to management activities (Herbes et al., 2017). Linking back to the typical cooperative member characteristics described earlier, the intensive use of members' time resources favours certain societal groups to pursue cooperative activities. The aspired ideal of cooperatives to be generally inclusive for all societal groups is therefore often not achieved and their member structure only reflects the cross-section of society to a limited extent.

In comparison to the cooperative's legal structure, the association operates within a looser framework. Certain economic responsibilities are simplified for associations, because of their non-profit obligation. Under the German civil law code (BGB, 1896/2002), there are two types of associations: an association and a registered association. An association needs at least two founding members and a founding protocol. In case of registering, seven members and a statute are required. Statutes do not have to be publicly available, but an association has to have its office within Germany. Associations, which pursuit charitable goals, are exempted from taxes (BMJV, 2016).

Associations usually act as networking platforms, thereby informing about wind energy for proponents as well as opponents about wind energy projects, but may also be found in project operation structures. The non-profit obligation of associations makes the acquisition of capital for projects difficult. Therefore, the legal structures including associations for renewable energy production frequently also include for-profit entities (e.g, GbR) and hence form a hybrid structure (Holstenkamp, Kahla and Degenhart, 2018). The associations in such a hybrid structure serve to disperse liability risks. An example for a hybrid structure is the project "Dörpsmobil", including a limited liability company for wind energy production and an association to manage the connected car sharing.

A common form of local financial participation of citizens in Germany provides the "Bürgerwindpark" concept, which is not specifically tied to one legal structure per se (Maly, Meister and Schomerus, 2018). The idea of a "Bürgerwindpark" is to provide financial shares to affected citizens of a wind park project and hence increase citizen acceptance among them. Maly, Meister and Schomerus (2018) find that suitable legal structures for such projects are limited liability companies, cooperatives or foundations. As several actors are typically engaged as shareholders in wind projects, the facility operation is often transferred to a limited liability company ("GmbH") or limited partnership ("KG"). These legal forms are difficult to categorise in terms of compliance with characteristics of citizen-led initiatives (Holstenkamp et al., 2018), because this would require knowledge about the underlying shareholding structure in detail. For example, a limited liability company that is 100% owned by cooperatives is complying with the principles of a citizen-led initiatives, whereas ordinary corporations under the same legal form do not comply with the principles.

Name (ruling law)	Founding requirements	Other specifications
Cooperative (GenG)	Formally agreed upon in an obligatory statute Nominal capital can be outlined in the statute Official registration, if registered 3 founders	Tied to cooperative principles Liability of members limited to their shares
Association (BGB)	Articles of association No nominal capital Official registration, if registered 7 founders, if registered	Tax-privileged body, if charitable
GmbH (GmbHG)	Articles of association Nominal capital: 25,000 € Official with registration 1 founder	Special form gGmbH, when only non-profit purposes Liability with nominal capital
KG (HGB)	No nominal capital Official with registration 2 founders	Personal liability of associate(s)
GbR (BGB)	Articles of association 2 founders	Personal liability of associate(s)
Foundation (StiftBTG)	Using statute Nominal capital: foundation assets Official with permit 1 founder	Tax-privileged body, if charitable Activities tied to foundation purpose

Table 2.4: Characteristics of identified legal forms of citizen-led initiatives (sorted by relevance high-low).

A foundation can also function as a possible legal body for citizen engagement, often containing some charitable element. In contrast to most of the other legal forms, the possibilities to get involved in wind energy tend to be restricted to engagement on a more informational basis rather than on an operational level. To the best of my knowledge, only one foundation in connection to wind energy production exists in Germany, which is called ”Stiftung Klima”. Their mission is to inform about the benefits of renewable energies, rather than taking part in any production themselves. They receive funding from the United States of America.

2.2 Legislative frameworks

National renewable energy markets are determined by their legal frameworks (Herbes and Friege, 2017, p. 28). As part of the European Union, Germany is obliged to follow enactments on EU level (see Figure 2.5). The major EU strategies concerning the energy sector are the EU Climate and Energy package, and the EU Green Deal (BMWi, 2021c). To enact the mentioned strategies, several statutory orders are in place. They are concerned with the topics emission trade, energy efficiency, environmental protection, fossil energy sources, energy infrastructure and energy market with intra-European electricity trade.

On the national level, the strategic framework for the energy sector is called ”Energy concept of the national government”. This concept was enacted in 2010 and outlines the guiding principles for the transition towards renewable energy production. These principles are affordable and secure energy supply, and environmental friendly production of energy (BMWi, 2010). In addition, the nuclear

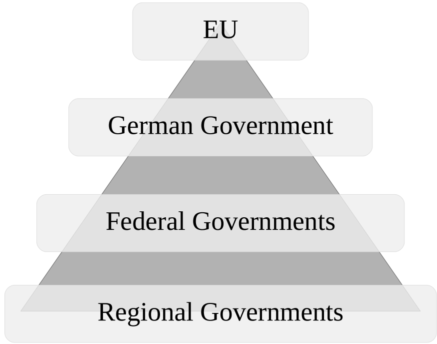


Figure 2.5: Schematic description of vertical political and legislative structure in Germany, own figure.

phase-out is laid down in the document. On the national level, the most important laws for wind energy production include the Renewable Energy Sources Act, environmental and emission regulating laws (e.g., BNatSchG, UVPG), energy infrastructure acts (e.g., NABEG, EnLAG), and market regulation and taxation (e.g., EnWG, EnSiG, StromStG, EnergieStG). These laws are connected to specific enactments, which are summarised on the legislative map (see Fig. 2.6).

Following the vertical legislative structure, downwards, federal and regional governments have to translate the concepts and laws in compliance with the upper level to their regional needs. This results in an great number of different specified targets for the regional development of renewable energy production (c.f. UBA, 2019b).

In conclusion, the high amount of legislative expertise that is needed in order to understand the regulative body may pose a serious challenge to citizen-led energy projects. In addition, the regulatory differences on the federal level provide varying prerequisites for those projects throughout the country. The next sections provide further details on selected legislation, relevant for energy cooperatives and other legal forms.

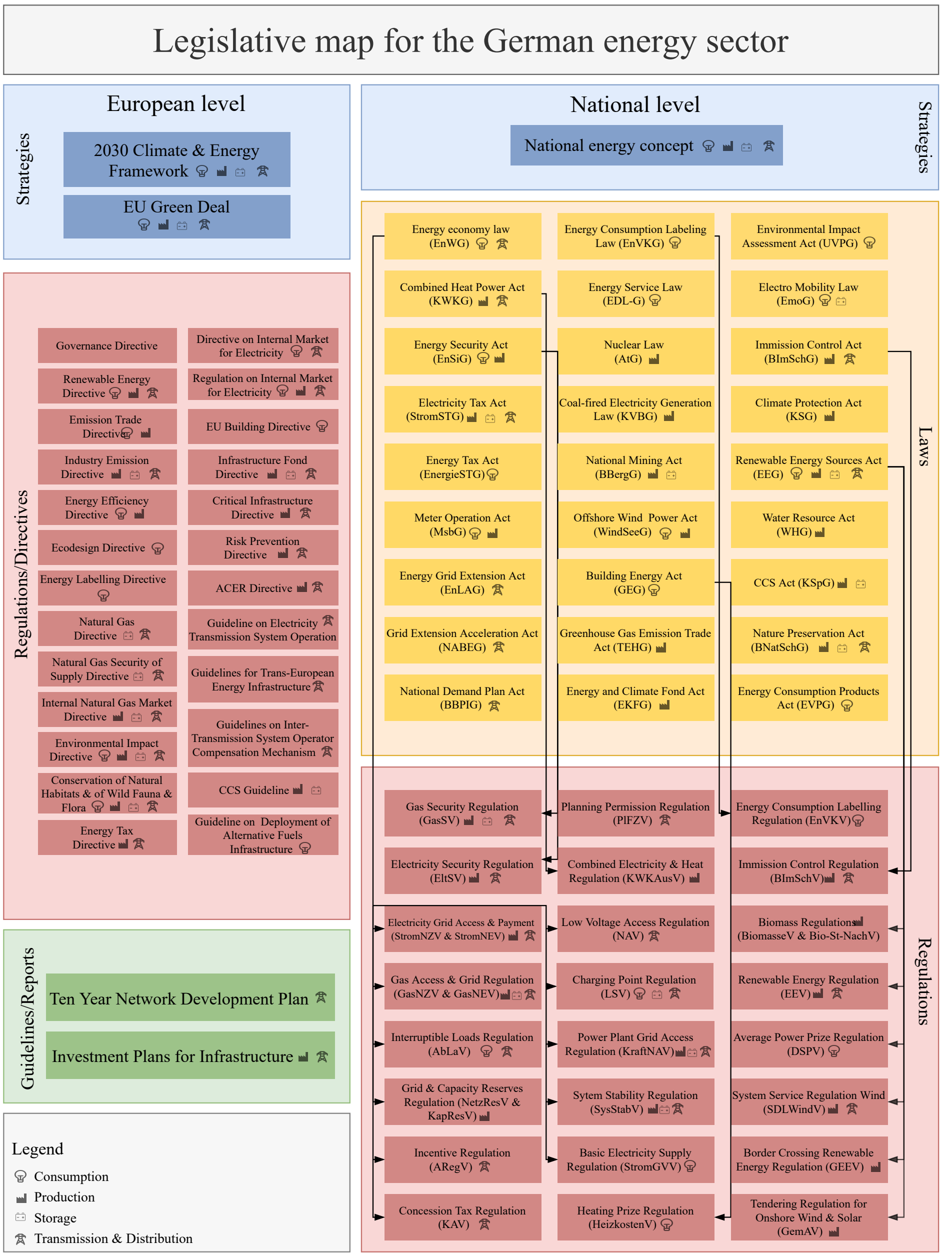


Figure 2.6: Legislative map for the German energy sector, displaying on the left hand side European strategies, directives and guidelines, and on the right hand side German strategies, laws, and regulations. The map is based on BMWi (2021c). Original map with links to laws and regulations available at www.bmwi.de.

2.2.1 Renewable Energy Sources Act

In Germany the most important legal framework for renewable energies is the Renewable Energy Sources Act - EEG. Over the course of the last two decades the support scheme for renewable energies developed from a fixed feed-in tariff to the present tendering scheme. Both schemes are regarded as typical for a national support for the renewable energy market and are widely applied (Herbes and Friege, 2017, p. 28-29). Feed-in tariffs guarantee producers a fixed price for their renewable electricity feed-in over a 20 year span, depending on the employed technology. Tendering schemes are characterised by a clear competitive component, regulating the distribution of support in a market-like fashion. In the tendering support scheme, market actors bid for 20 year state remuneration and the lowest bids within a set development volume are receiving support. It is worth to remind the reader that the national energy policies were influenced by EU regulation and pushed towards tendering schemes (Herbes et al., 2020).

Table 2.5 provides a summary of the development and amendments of the Renewable Energy Sources Act relating to onshore wind power production. Before the amendment in 2017, the German state supported onshore wind power production with a fixed remuneration known as a feed-in tariff. The electricity producer was guaranteed a fixed price over the course of 20 years from the grid operator for feeding his produced electricity into the grid. This price was adjusted due to several technological and market developments, which reflects in the numerous amendments (see Tab. 2.5).

The most significant adjustment for cooperatives yet was the change from a fixed feed-in tariff as a remuneration to a tendering scheme, discussed for example by Lundberg (2019). In the tendering scheme, market actors are bidding for state support of their projects. In general, the lowest support bids for the announced tendering volume (capacity of onshore wind) win a fixed support according to their bid over a 20-year-timespan. For the first tendering rounds in 2017, energy cooperatives had a special stands in the bidding scheme to promote actor diversity. They were exempted from the obligation of having a Federal Immission Control Act permission prior to entering the auction (exemption clause). Furthermore, the price for entering a bid of 30 EUR/kW was divided into two equal parts for cooperatives to reduce the up front investment. This means they had to pay half the price to enter the auction and in case of a successful bid the other half had to be payed. These so-called bid bonds are returned after successful commissioning of the project. Additionally, the remuneration was not coupled to their bid (pay-as-you-bid), but to the highest winning bid of the tendering round. Lastly, the realization deadline for cooperative projects is 54 months, with penalty fees after 48 months. Other participants have 30 months to complete their projects and are object to penalties after 24 months (Lundberg, 2019). In 2018, the exemption clause for cooperative projects was withdrawn, equating cooperatives with other actors in the wind sector. They now have the same obligation for an Immission Control Act permission, and an realization time of 30 months (Lundberg, 2019).

Year	Type of support scheme	Targets	Changes for onshore wind energy
2000	Feed-in: remuneration paid for production amount, than reduced for remaining 20 years; 2002: decrease of remunerations 1.5% yearly	Double the share of renewable energy by 2010	Grid operator obligations: purchase of renewable energy; grid reinforcements due to new production demand plant operator obligation: grid connection
2009	Feed-in: increase from EUR 8.03 to EUR 9.2 cents/kWh for initial 5 years, afterwards decrease to EUR 5.02 cents/kWh with decrease rate of 1% annually		re-powering eligible to support for 10-year old turbines and new turbines with at least twice the capacity, but maximal five times the original capacity
2012	Feed-in tariff	Minimum renewable share in electricity supply: 2020 (35%), 2030 (50%), 2040 (65%), 2050 (80%)	Starting remuneration of EUR 8.93 cents/kWh decreases annually with 1.5%, re-powering bonus only granted to turbines commissioned before 2002
2014	Feed-in tariff	Minimum share of gross electricity consumption from renewables: 2025 (40%-45%), 2035 (55% - 60%), 2050 (80%); 2.5 GW onshore wind capacity increase yearly	Obligation for direct marketing; exemption: power plants commissioned before 2016, ≤500 kW Domestic consumption surcharge for new "auto supply"-units
2017	Tendering volumes for 20 years support: 2.8 GW yearly until 2019 2.9 GW yearly from 2020	unaltered from 2014	From May 2017, 3-4 tenders per year Price ceiling of EUR 7 cents/kWh Required permits must be submitted 3 weeks before the tendering round
2021	Tendering for a set support over 20 years	2050: 100% carbon neutral electricity production and consumption in Germany development targets set to reach 65% target by 2030	Municipal financial share for wind energy development Reduction of costs (e.g., adjustment of max. value for tenders) and innovation support (innovation tendering) Incentives for new digital technologies (smart-meter-gateway); "south quota" for onshore wind to balance development and grid extension End of support onshore wind (non-repowerable); extension of support until 2023 possible, due to lower electricity prices during COVID-19

Table 2.5: Development of the Renewable Energy Sources Act by year regarding onshore wind power production in Germany. Information sourced from IEA (2021) and BMWi (2021d).

2.2.2 Other legislative frameworks

Besides the Renewable Energy Sources Act, the most important legislative frameworks for the planning and building process of a wind turbine in Germany are the National Immission Control Act (BImSchG), the federal Building Codes and Zoning Plans, and the Nature Preservation Act (BNatSchG).

The Immission Control Act regulates technicalities regarding the pollution of construction projects (e.g., noise pollution of wind turbines), by setting certain thresholds. Every wind project has to obtain a permission in accordance with the act beforehand, to make realization possible.

Federal or regional zoning plans designate certain areas as wind development zones. Within these zones, wind power is the prioritized land-use and wind turbines can be build.

The Nature Preservation Act protects endangered ecosystems and species. If a wind project is threatening either an endangered ecosystem or species during the building or operation process, special measures have to be applied or, in more severe cases, the project has to be aborted.

In comparison to conventional power plants onshore wind power production is spatially intensive. The development is therefore restricted by the availability of suitable sites. Suitable sites are both restricted by wind conditions and spatial regulations on a national and federal level. An example for regional specific regulations can be found in the federal state of Bavaria, where wind turbines have to be placed at least ten times their height away from residential settlements, thus reducing areal availability. A study conducted by the German Environmental Agency (UBA, 2019b) reports a sufficient availability of space in the medium term until 2025. More precisely, according to current development goals, the available area exceeds the demand by 60%. Due to large uncertainties in the process of calculation (e.g., regulatory developments), the authors expect a potential shortage of areas for wind development by 2030. The calculations still yield a small excess, but are interpreted as concerning for the aspired development goals due to the high level of uncertainties associated with regional legislations. The calculation for spatial availability includes the option of re-powering. Between 2000 and 2014, UBA (2019b) reports, that 23% of areas dedicated to wind energy production were not developed because of nature and species protection concerns. Thus, if this trend continues, an additional threat is posed on wind development projects in the coming years.

On the supra-national level, the EU sets the framework with the European Green Deal as a road map to net carbon neutrality of the EU until 2050. Within this overarching strategy several frameworks are anchored. One of them, which is important for the wind power development, is the 2030 Climate and Energy Framework. Currently, the framework includes the following targets:

- 40% cuts in greenhouse gas emissions compared to 1990 levels
- 32% share for renewable energy
- 32.5% improvement in energy efficiency

However, at the end of 2020 the EU commission proposed to increase the CO_2 reduction targets to 55% compared to 1990 and will propose an updated set of targets in summer 2021 (EU, 2021).

Chapter 3

Methods for analyzing citizen-led wind energy projects

3.1 Statistical analysis

For this master thesis, I extended a database compiled within the European COMETS project (Wierling et al., 2021b). The COMETS project is funded by the EU Horizon 2020 research and innovation program, and deals with collective action in energy transitions and associated social innovations. To examine collective action throughout Europe, data on various forms of citizen engagement in the energy markets is collected. In the case of Germany, the focus mainly lies on cooperatives. In the context of this thesis cooperatives, as a major example of citizen-led initiatives, are used to explore citizen-led wind power projects in Germany. Next, the data collection method will be described.

The starting point for the data base extension formed a key word search in the Core Energy Market Data Registry (Bundesnetzagentur, 2021b). Here, the search terms ”Genossenschaft” and its common abbreviations ”eG” or ”e.G” were used in the search mask for wind turbine operator’s name. It has to be noted that the choice of search term allowed results to have a mixed legal forms, like a combination of cooperative and limited company (”eG & Co KG”). Following the initial identification, the websites of the cooperatives were scanned in order to get additional information (e.g., percentage of shareholding, other wind projects, etc.), and also used to crosscheck and verify information.

Cross references on websites of cooperatives or wind park projects led to new information about cooperative shareholders, which were then integrated into the database. In many cases, cooperatives are main shareholders of limited liability companies, which are solely founded for the operation of a wind turbine. Those production units were not captured by the initial search. For this reason, the sampling procedure was applied inversely. The identified associated limited liability companies’ names were checked in the Core Market Data Registry for further information. For initial identification of shareholdings on the cooperative website of production units, certain specifications were used, such as location of the turbine/s and name of the operator, to merge information with the Core Energy Market Data Registry. In case of shareholdings on wind parks, the procedure partly delivered a higher precision, identifying the ownership of single units.

In addition to the exploration of the cooperative data, a search for the term ”wind” in the name field of the German Association Registry (Land Nordrhein-Westfalen, 2021) was conducted. Using this filter, possible registered associations as a form of citizen-led engagement in the wind energy sector were identified. This additional search further broadens the perspective of the thesis work and provides context. The search results were crosschecked with websites and categorized into ”no-wind energy connections”, ”wind energy proponents” and ”wind energy opponents”.

The underlying database for this master thesis is available as an open source database with the finalization of the COMETS project in Spring 2022.

3.1.1 Data quality

Crosschecks were conducted between the different sources and the four-eyes principle was applied to ensure high data quality throughout the dataset. Furthermore, the final check of entries in the Core Energy Market Data Registry took place after the 31.01.2021, which was the registration deadline for wind production units under the Renewable Energy Sources Act (Bundesnetzagentur, 2021d). This leads to a high confidence in the completeness of the search results, since there are penalties for later registration of already commissioned units. Time effects on the data sampling were minimized by checking the data compilation within the time frame (16.03.-04.05.2021).

Data source	Gathered data	Problems	Conventions
Cooperative websites	Names of production units, capacities, shareholding, project partners,	Discrepancies with official registry	
Core Energy Market Data Registry (Bundesnetzagentur, 2021b)	Names of production units & wind parks, geographic locations, date of commissioning, capacity of production units, full or part grid feed-in, turbine type	Discrepancies between website information and official registry;	If discrepancy identified, official registry overrules website information
Commercial Online Registry (Registeranzeiger GmbH, 2021)	Names of cooperatives, national identifier	Frequent updates, changes of identifiers	
Commercial Registry (Land Nordrhein-Westfalen, 2021)	Date of foundation	Systemic error in data possible due to merging of registry portals after the German reunion	Overrules date of foundation found on websites

Table 3.1: Data sources for the COMETS database.

When conflicting data was encountered during the sampling process or information was missing, a set of conventions was applied to secure the same quality across the gathered data. Firstly, data from official registries was expected to be checked and updated more often, and thus overruled conflicting data from websites. Secondly, for incomplete entries in the data set with several turbines (e.g., whole wind parks), where the ownership was not clearly distinguishable for a single production units, the location coordinates were retrieved from the 1st production unit either by name or date of production start. This approximation is regarded to be sufficient to create a national overview of cooperative wind production units. All units, where information on shareholdings was present, but no details on the distribution of shares, were marked as unclear shareholdings. For production units with nonexistent information about shareholdings on cooperative websites of identified units, the Core Energy Market Data Registry or other sources, 100% ownership was attributed to the operator.

The main source for the collection of data were the cooperative websites in combination with the official German registry portals (see Table 3.1). Especially, the Commercial Online Registry (Registeranzeiger GmbH, 2021) was frequently updated during the sampling process and changes in the national identifiers were observed. As national identifiers were added onto the list of previously unique identifiers, and not replaced, the changes should not have affected the quality of the sampled data. The official registries mainly deliver unified amount and precision of data for all entries. In contrast, cooperative websites vary greatly in the degree of detail of provided data, ranging from only the provision of single project names to an extensive documentation of financing and production data for single production units.

The Core Energy Market Data Registry (Bundesnetzagentur, 2021b) provides data per production unit, where a unit is defined as a single wind turbine. The systematic search on the cooperative websites provided further data on current activities of the cooperatives, which provided valuable contributions for the business model canvas. The Energy Market Data Registry provided the following categories: names of production units as well as names of wind parks, geographic locations of production units, the date of commissioning and the type of grid feed-in of the electricity (full or part feed-in). The Commercial Online Registry (Registeranzeiger GmbH, 2021) lists general information about cooperatives, including official names, national identifiers, activity status of the entity, registered address and the federal state of origin. The Commercial Registry (Land Nordrhein-Westfalen, 2021) was consulted to acquire the date of foundation of the respective cooperatives.

3.1.2 Statistical tools

This study deploys two types of statistical tools, namely quantitative analysis of the database in RStudio (2020), and a systematic review of cooperative websites to complement the described data. For the map displaying the wind power project distribution across Germany an R-script from Wierling (2021a) was used (c.f. Section 4.1.1). The business model canvas, developed by Osterwalder et al. (2010), was used to aggregate both types of analysis, and visualize the results on a single page. The business model canvas is introduced in Section 3.2.

3.2 Case study method

The case study method was chosen to explore cooperative activity in the energy transition, because comparative analysis is suitable for studying basic methodological problems (Ragin, 2014) and for complex initiative structures (Yin, 2013). In comparison to multinational studies, smaller studies (e.g., national level) are more specific and thus relevant for the social basis of a specific phenomenon in reality. Nevertheless, a generalisation of a case study has an inherent risk of being biased towards the chosen subject of study (Ragin, 2014). A classical case study provides an in depth investigation of the case, but should consider further connections with its environment (Yin, 2013).

In this master thesis the multi case study approach aims to provide insights into two contrasting representatives of cooperatives active in the wind energy market. The approach is applied to get a broad picture of the present cooperative actors and to emphasize differences in the applied business strategies and their underlying models. Table 3.2 shows the contrasting characteristics of the two case studies.

Characteristics	PROKON regenerative Energien eG	Energiegenossenschaft Starkenburg eG
Year of cooperative foundation	2015	2010
History	Former GmbH founded 1995, change of legal form after insolvency	”Classical” cooperative history, citizen initiated project
Headquarters	Schleswig Holstein	Hessen
Business focus	International	Regional
Members (in 2020)	39461	955
Number of wind projects in Germany	287	7
Costs for mandatory membership share	50 EUR	200 EUR (+1800 EUR as project specific loan)

Table 3.2: Comparison of characteristics of case studies. Sources official websites and COMETS database.

For this master thesis, PROKON regenerative Energien eG and Energiegenossenschaft Starkenburg eG were selected as case studies, due to their contrasting characteristics (see Tab. 3.2). PROKON regenerative Energien eG is currently by far the largest wind cooperative in Germany. It originated from a former limited liability company and currently has about 287 wind projects across Germany. In contrast, the second case study Energiegenossenschaft Starkenburg eG evolved classically from a group of 12 citizens and is today a medium-sized wind cooperative, managing seven regional projects. Geographically, PROKON regenerative Energien eG operates on an international scale, owning wind production units in Finland and Poland as well as in Germany. However, this thesis will only focus on the production facilities within Germany. Furthermore, the cooperative originates from northern Germany, whereas Energiegenossenschaft Starkenburg eG was founded in mid/southern Germany. Not only the size of both cooperatives is sharp contrast, but also the size of financial investment to acquire the mandatory shareholdings for members. Energiegenossenschaft Starkenburg eG offers their membership for a minimum financial commitment of at least 2000 EUR. PROKON regenerative Energien eG in contrast offers membership shares at a price of 50 EUR per membership share. Notably, both strategies seem to be successful, since membership numbers over time show a rising trend throughout the histories of both cooperatives.

To analyse and categorize the gathered data from the COMETS database and website reviews, the structure of the business model canvas by Osterwalder et al. (2010) was applied (Fig. 3.1). Both, for the case studies and the general data, the investigation of this structure provides the backbone, creating a comprehensive and comparable investigation of cooperative business characteristics.

The business model canvas from Osterwalder et al. (2010) is a suitable choice, as its applicability to study cooperative business models in a transformation has already been demonstrated (e.g., Dilger, Konter and Voigt, 2017; Ehrtmann, Holstenkamp and Becker, 2021; Herbes et al., 2017). Dilger, Konter and Voigt (2017) expanded the business model canvas by customizing it to the specific member focus of cooperatives. Figure 3.1 depicts the data sources for the business model investigation as well as the applied modified canvas structure.

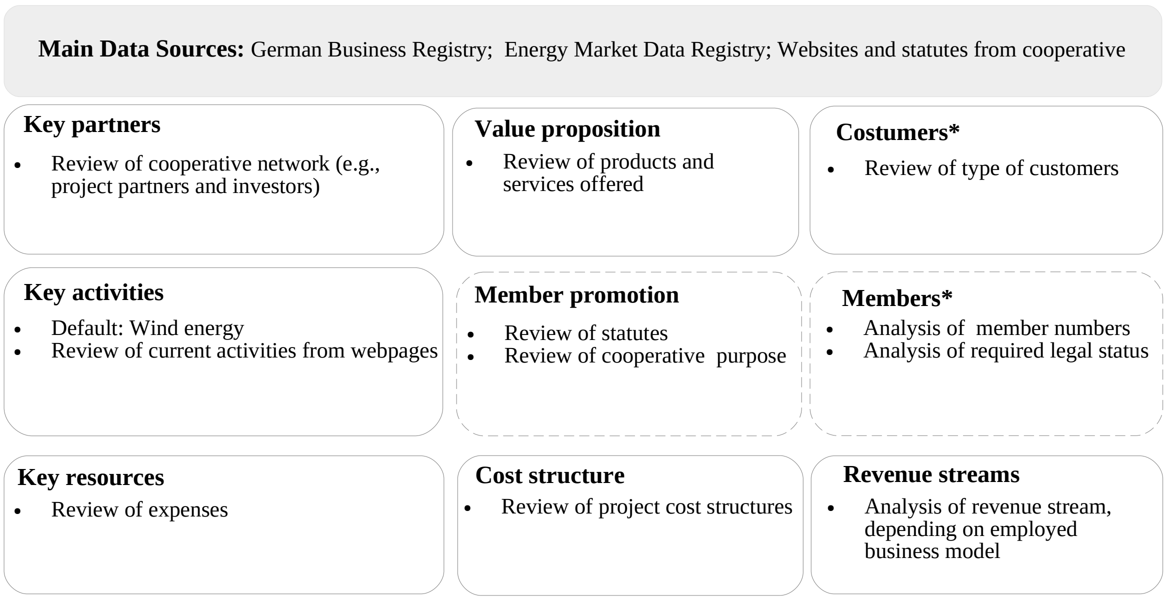


*Figure 3.1: Data sources and methods for business model canvas of wind cooperatives modified after Osterwalder et al. (2010) in solid lines and dashed lines Dilger, Konter and Voigt (2017). Overlapping categories are marked with *.*

As there is a large number of different definitions of business models among different fields of application for the tools like a business model canvas, this part starts with stating the underlying definition used for this master project. A business model describes the structure for value creation of a company and its delivery to the customer (Teece, 2018). The aim of a business model is to provide a tool to create a condensed overview of structural characteristics of an enterprise and thereby illustrate, for example how the enterprise is able to create profit. The business model builds the core of a company's operation and success, but the actual success additionally depends on the implementation of the structure in form of employed technologies, operation of assets and equipment (Teece, 2018). With regard to business model innovation or transformation, Teece (2018) notes, that easy transitions are possible if the new business model fits into the old framework. However, this is likely not sufficient to restore a market position under attack by competitors.

The original customer-focused canvas from Osterwalder et al. (2010) is partitioned into nine categories:

1. Key partners: ranging from commercial to political partners.
2. Key activities: the action a company takes to run the business.
3. Key resources: main assets to create specific value proposition.
4. Value proposition: creating customers satisfaction.
5. Customer relationships: the maintenance and development of interaction with customers.
6. Channels: the mode of delivery of the value proposition (e.g., communication, distribution).
7. Customer segments: ranging from one to several customer segments.
8. Cost structure: the financial backbone of a business.
9. Revenue streams: the cash flow generated from customer segments.

Thus, the business model is characterized by building blocks and their connections between them (e.g., customer relationship, channels). A business model usually does not serve the purpose of providing a detailed investigation of an applied business structure, but rather to give a single page overview of key components. It is commonly used as a brainstorming tool.

Throughout the Renewable Energy Sources Act, cooperatives faced new challenges, such as changes in the support framework. For a comprehensive overview of cooperative business model literature (2012-2016) see Herbes et al. (2017). Initial business models were typically based on an easy and risk-free use of fixed feed-in tariffs, which were guaranteed by the state over a period of 20 years (Herbes et al., 2017). With the more recent amendments of the Renewable Energy Sources Act, the change towards market-based tendering, impacted and challenged cooperatives to transform their initial business models (Herbes et al., 2017; Klagge and Meister, 2018).

With regard to cooperative business models, a special attention has to be paid to the members as the steering committee of the enterprise. Therefore, Dilger, Konter and Voigt (2017) extended the original canvas by including members and member promotion as categories (c.f. Fig. 3.1). The category members interferes in the canvas with customers, as members are inheriting both roles in one person.

For the analysis of the case studies, the extended business model canvas from Osterwalder et al. (2010) was operationalised as a framework to ensure comparability. As a main source to complement data gathered in the database, a detailed review of the cooperative websites was conducted. Through the review, project partners and the history of the cooperatives was investigated. The review of key partners was supplemented by findings of an external data analysis. The external providers North Data GmbH (2021) and webvalid GmbH (2021) gather network analyses data, which were assembled to be able to sketch the current business network of both case studies. The results are shown and discussed in Section 4.2 and 4.3.

Chapter 4

Citizen-led projects in the German wind sector

4.1 Statistical insights

4.1.1 Cooperatives

In the data compilation process, 136 active cooperatives in the wind sector were identified with a total amount of 597 production projects. The term production project refers either to a single turbine or a wind park shareholding containing several units. In case of shareholdings multiple entries for the same project might exist, as several cooperatives can be shareholders in the same project. The cooperatives with the biggest production unit portfolio in the data set are PROKON regenerative Energien eG and Greenpeace Energy eG, who also have an supra-regional, even international investment area. The presentation of the statistical insights starts with an analysis of additional fields of activities of wind cooperatives, and is followed by spatial observations of their activity. The Section ends with a description of characteristics of cooperative wind projects.

Table 4.1 shows additional activities of the wind energy cooperatives in the data set. In addition to the default onshore wind energy activity, most cooperatives also engage in solar photo-voltaic (68%). In comparison to wind power production, there are lower investment hurdles for the acquisition of solar panels and they employ less complex technical systems.

The second most abundant cooperative activity is electricity trade (26%). Depending on the size and capacities of the cooperative the trade is commonly realized through partnerships with electricity suppliers. Typical partners in electricity supply are naturstrom vor ort GmbH and the cooperative umbrella organisation Bürgerwerke eG.

Under the category heat, most commonly wood chip heat contracting is found, where cooperatives exchange old heating systems with state-of-the-art wood ovens. They receive payments for efficiency gains and/or maintenance services.

In connection to agricultural production, biogas was often used as an additional source for electricity production. Cooperatives active in agriculture consist of historically grown structures, as they were founded in the early 1990s (see Fig. 4.4(b)).

Activity	Number of cooperatives
Solar photo-voltaic	92
Electricity trade	36
Heat (contracting, supply)	21
Bio gas	16
Agriculture	9
Consulting and financing	8
Hydro power	8
Combined heat and power (CHP)	6
Natural gas	6
Operation of electricity grid	4
Solar thermal	1
Water supply	1
Broadband internet	1
Transport/mobility	1
Other, unlisted activity	20
Energy production as secondary activity	15

Table 4.1: Additional activities of identified wind cooperatives. Note: Multiple additional activities per cooperative are possible. Source COMETS database.

In the category consulting and financing cooperative banks are found. They are not only important partners in financing of cooperative projects, but they also operate wind power plants themselves. Cooperative consulting includes the provision of information on heat and electricity efficiency measures. Combined heat and power devices produce electricity and at the same time the process heat is used as source for warmth, thus increasing the overall efficiency of the system. Those systems are typically fueled with fossil or renewable fuels, like bio gas.

A minor share of wind cooperatives additionally engaged in natural gas sales, the operation of an electricity grid, solar thermal power generation, water supply, internet infrastructure, or transport and mobility solutions (e.g., car sharing). In addition, 20 cooperatives were found to have activities, which could not be classified according to the above mentioned categories. The 15 cooperatives, which are not primarily active in energy production are originating mostly from the agricultural (9) or banking sector (3).

Overall, cooperatives in the wind energy sector are characterised by a diverse activity portfolio. This diversification is expected to be a reaction to increasing market pressures and will likely to continue in the future with cooperative business model innovations (Klagge and Meister, 2018; Wierling et al., 2018). The attributed low resilience of citizen projects (Brummer, Herbes and Gericke, 2017), may also be increased by energy cooperatives through diversification.

For 522 out of the 597 identified cooperative projects, geographical coordinates have been obtained and plotted in a map (Fig. 4.1). Despite a 40% higher average wind speed in northern Germany (Unnerstall, 2017), the distribution of cooperative wind projects is spread relatively equal over the whole country. Hot spots with a large number of projects are especially found in the middle and north-eastern parts of Germany.

The investigation of the headquarter locations of the cooperatives in the

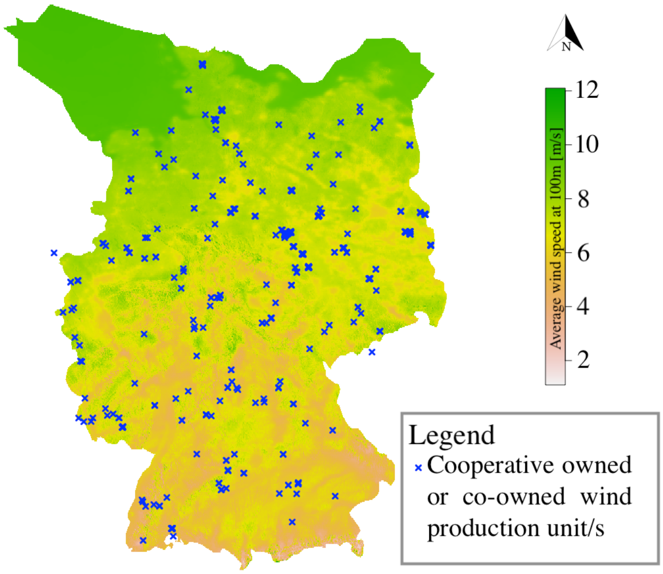


Figure 4.1: Map of cooperative owned or co-owned production units in Germany. Source COMETS database; raster map retrieved from DTU (2021).

dataset reveals that the majority of wind active cooperatives are founded in the southern states Bavaria, Baden-Württemberg and Hessen (Fig. 4.2). This contradicts the perception of mostly regional cooperative action (DGRV, 2019). The southern part of Germany includes the wealthier federal states and hosts economic hot spots, which may create the expectation that more private capital is available in these regions. In connection with the generally greater economic wealth, more citizens in the south may have the financial resources to invest into wind power. Typically, cooperative members obtain their financial resources from above average incomes (see Section 2.1.3). Former research from Wierling et al. (2020) reports a correlation between high income areas in southern and western Germany and the activities of solar PV cooperatives. In comparison to commercial market actors, cooperatives also have less profit focus, as they also pursue a social vision. However, the profit orientation differs among energy cooperatives. Holstenkamp and Kahla (2016) find that there is a higher profit orientation of cooperatives in the northern parts of Germany than in the southern. Thus, higher profit expectations may lead to a lower amount of suitable citizen projects, and in turn also lead to less wind energy cooperatives in northern Germany. This translates into the overall impression that capital from south Germany is financing the wind power production in the northern parts. This may also affect the acceptance debate, because the profits are realized and "shifted" to the south, while citizens in the northern parts have to arrange themselves with production facilities in their backyard.

The development of the cooperative wind capacity is given as a minimum (1,006 MW) and maximum capacity (1,888 MW) due to missing information about shareholdings. The minimum value was retrieved by setting all the unclear shareholdings to 0% and the maximum value respectively to 100%. The results are shown in Fig. 4.3. Capacity peaks in the first decade of the 2000s in Fig. 4.3, are associated with the early development from the PROKON erneuerbare En-

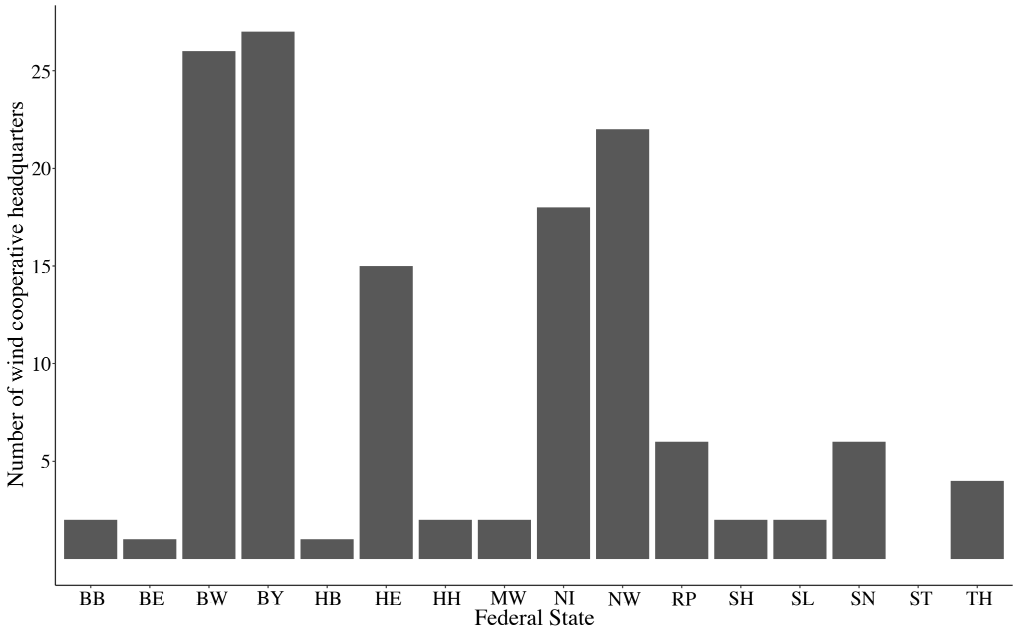


Figure 4.2: Location of wind cooperative headquarters, source COMETS database. Federal states: Baden-Württemberg (BW), Bavaria (BY), Berlin (BE), Brandenburg (BB), Bremen (HB), Hamburg (HH), Hessen (HE), Mecklenburg Western Pomerania (MV), Lower Saxony (NI), Northrhine-Westphalia (NW), Rhineland Palatinate (RP), Saarland (SL), Saxony (SN), Saxony-Anhalt (ST), Schleswig Holstein (SH), Thuringia (TH).

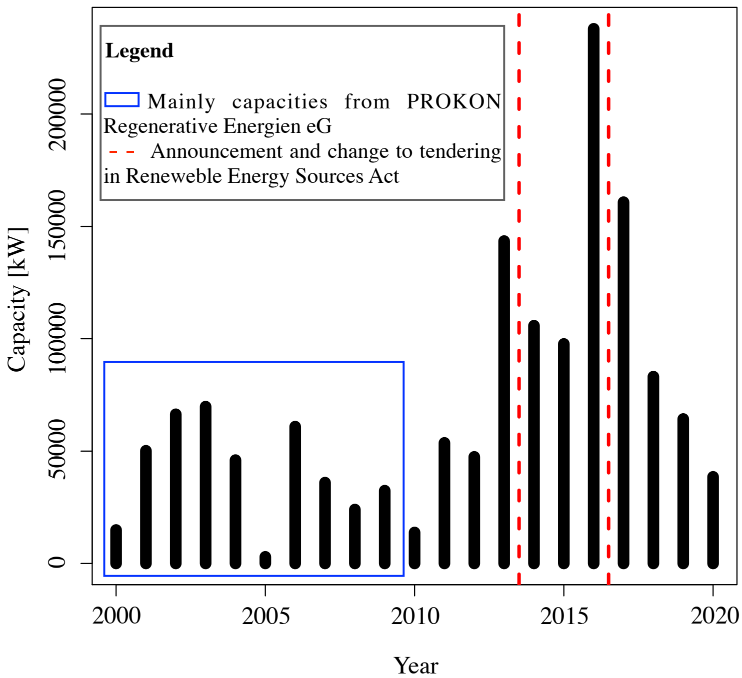
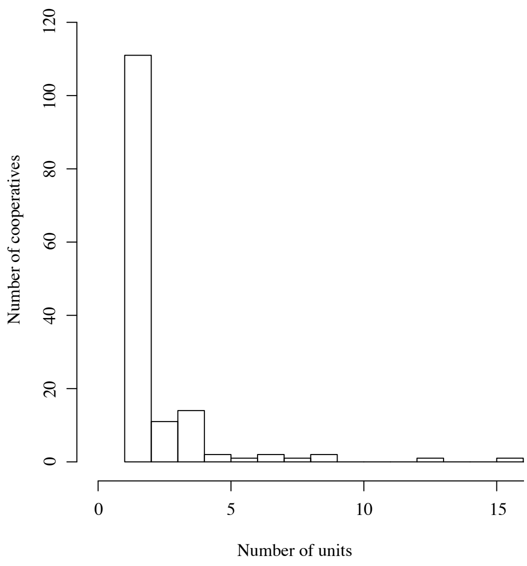


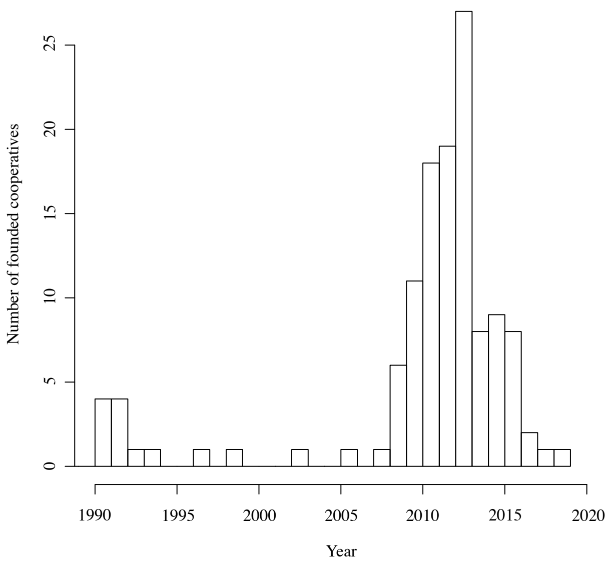
Figure 4.3: Commissioned cooperative wind power capacities by year (upper limit), source COMETS database.

ergien eG as a former limited company (see Figure 4.7). When these are masked, a pronounced peak in capacities is visible in 2013 and 2016, right before the major changes in the Renewable Energy Sources Act 2014 and 2017 towards a tendering procedure for the remuneration of wind energy. 2017 shows, compared with the former years, an exceptionally high number of new capacity additions, which coincide with the success of cooperative projects in the first tendering rounds (c.f. Lundberg, 2019). From 2018 onward, a steady decline in newly commissioned capacities by cooperatives can be observed. Reasons for that may lie in the withdrawn exemption clause for cooperative wind projects after 2017 in combination with the support scheme change to tendering (see Section 2.2.1).

The number of projects per wind energy cooperative are shown in Fig. 4.4(a). The histogram is skewed with a median of one project per wind cooperative. Only three cooperatives have over 10 projects in their portfolio. The maximum number of projects combined under one cooperative belongs to PROKON regenerative Energien eG (cut in the graphic) with 287. The second biggest wind portfolio is held by the nationally operating Greenpeace Energy eG (16). The low median number of projects can be related to financial investments and risks (see Chapter 2). The generally risk-averse energy cooperatives are facing a trend of bigger wind project sizes and associated financial commitments. This trend favors partnerships to disperse project risks of cooperatives, and thus leads to wind project shareholdings. In the COMETS database, 26% of the total wind project entries are marked as shareholdings, accounting for about 50% of the non-PROKON projects.



(a) Number of projects per cooperatives.



(b) Foundation years of wind cooperatives.

Figure 4.4: Number of projects per cooperatives (cut 1-15) and foundation years of wind cooperatives in data set. Source: COMETS database.

Figure 4.4(b) illustrates that the cooperatives present in the data set were mainly founded between 2009 and 2016. Four cooperatives were founded before 1990. From 2007, the number of newly founded cooperatives rose steadily until it peaked in 2012. This peak is followed by a strong decline in 2013, plateaued until 2015 and further declined until 2020. This observation coincides with findings from Klagge and Meister (2018), who identify a similar pattern for German energy cooperatives' foundations. In comparison to Klagge and Meister (2018), Fig. 4.4(b) shows a three year long plateau after 2013, before it declines to the current level of foundations. This plateau was not visible in the data from Klagge and Meister (2018), since their data did not go beyond 2015.

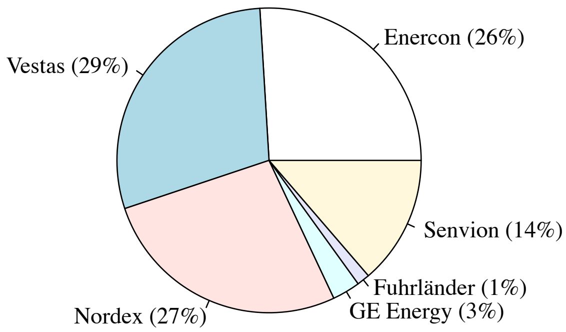


Figure 4.5: Share of wind turbine manufacturers in cooperative projects across Germany. Source: COMETS database.

The six most abundant wind turbine manufacturers identified, are shown in Fig. 4.5. In total they account for 439 of the identified projects. The majority of the projects were realised with Vestas wind turbines (29%), followed by Nordex (27%) and Enercon (26%). Overall the cooperative market for wind turbines is dominated by German turbine manufacturers, namely Nordex, Enercon, Senvion (insolvency in 2019) and Fuhrländer (insolvency in 2019). Vestas, a European competitor, plays a major role in the market as well, whereas the American General Electric (GE Energy) only occupies a minor role. In comparison to the overall market shares (see Fig. 2.1(b)), the cooperative projects have a 10% higher share of German wind turbine manufacturers (68%). This can be related to the regional anchorage and value proposition energy cooperatives are typically striving for. Furthermore, it might be a result of good service infrastructure.

4.1.2 Associations

A keyword search in the German association registry for ”wind” in the associations names delivered 152 hits as of 02.03.2021. Through a web search, 22 of these could be connected to activities concerning wind power. Out of these, 6 associations were identified as wind power opponents, associated with regional projects. Among the proponents of wind power, activities were mainly networking and consulting. A notable example among the associations is the European Academy of Wind Energy e.V., which is a Europe-wide network of research institutions who create a platform for collaboration in the field of wind energy. Their target group is the research community, fostering wind energy knowledge exchange, research, and education. Further information can be found on their website: www.eawe.eu.

4.2 Case 1: PROKON regenerative Energien eG

PROKON regenerative Energien eG is Germany's biggest energy cooperative (thereafter: PROKON). The cooperative has an unusual history, as it originates from a former limited entity. PROKON's headquarter is in the northern Federal State of Schleswig-Holstein, but wind power production units are nationally as well as EU-wide operated. The case study will proceed along the structure of the business model canvas (see Section 3.2) to ensure comparability with the second case study (Section 4.3).

First, to provide context for the case study, some historical facts are reported. The cooperative history started in 1995, when PROKON was founded as a limited liability company. The motivation was to create a commercial alternative to conventional nuclear power. The company purchased 1998 their first wind production units. In the following years, the company grew steadily and expanded their wind park portfolio as well as their infrastructure with over-regional service points in three northern Federal States.

In 2005, PROKON Energiesysteme GmbH owned 20 wind parks spread over five different federal states. Thereby, the company took care of financing, project planning, building, and technical and economical operation.

In 2008, PROKON internationalized and opened up its first office in Poland. The first international projects in Poland with almost 30 wind production units were finished in 2012. In the following years, the company extended its activity portfolio and offered the first electricity tariff on the market. The company generated the capital for investments from participation rights (”Genussrechten”) throughout the previous years to avoid dependencies on bank loans.

A loss of trust among the investors in 2014 forced PROKON into insolvency. The company was accused of using a Ponzi scheme to finance new investments (Süddeutsche Zeitung, 2014). To defend themselves from being bought by another big energy utility, the legal form was changed to a cooperative in 2015. From this point on, the company operates under the name of PROKON regenerative Energien eG. After 2017, the cooperative generated annual profits, paying dividends to their members.

PROKON's vision is described on their website as thriving for 100% renewable energies for the energy production to create a sustainable future. This vision should be realised by the society, including citizens, companies and decision-makers/politicians in the process. The mission as a cooperative is based on the benefit of the members, customers and the environment to contribute to climate and environmental protection. Sustainable energy production is seen as a contribution to the security of future energy supply and as an important contribution to the renewable-based change of the day-to-day energy mix in Germany. It is emphasized that the goal of sustainable energy production is a cooperative project and needs (active) citizen participation.

The business model canvas created for PROKON is shown in Fig. 4.6. The main field of activity is onshore wind power generation with a total of 394 wind turbines spread across Germany, Poland and Finland. Besides this main focus, the cooperative is also active in the planning and investment of solar photo-voltaic (ground and roof-mounted) electricity production units, and the trade of green electricity. Completing the list of activities, PROKON has contracts with a wall box installation company for electric vehicles providing members benefits in case of purchase.

The total onshore wind capacity identified from PROKON in the data set are 287 units accounting for 474.2 MW in Germany. The most recent financial record (Q2, 2020) describes 288 units throughout Germany. All units listed in the COMETS data base are specified as 100% owned by the cooperative. In the portfolio of 287 units listed, 283 were commissioned before change of the legal

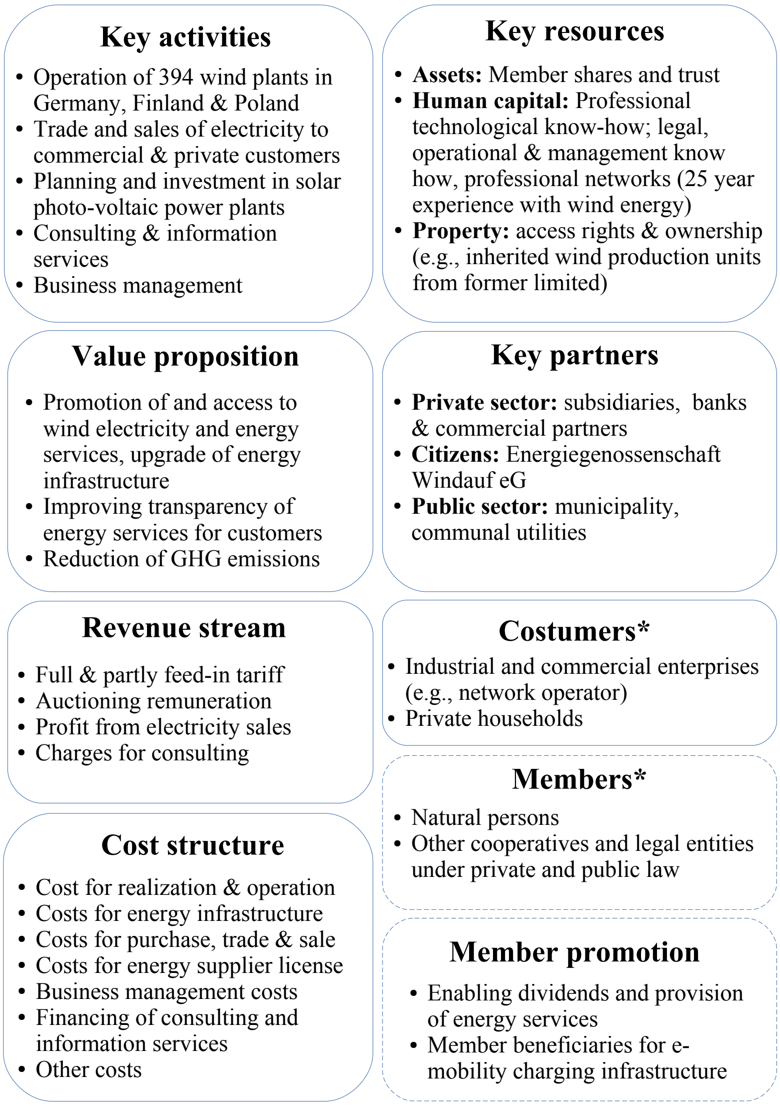


*Figure 4.6: Business model canvas for PROKON regenerative Energien eG. Own figure, based on structure by Osterwalder et al. (2010) and Dilger, Konter and Voigt (2017). Overlapping categories are marked with *.*

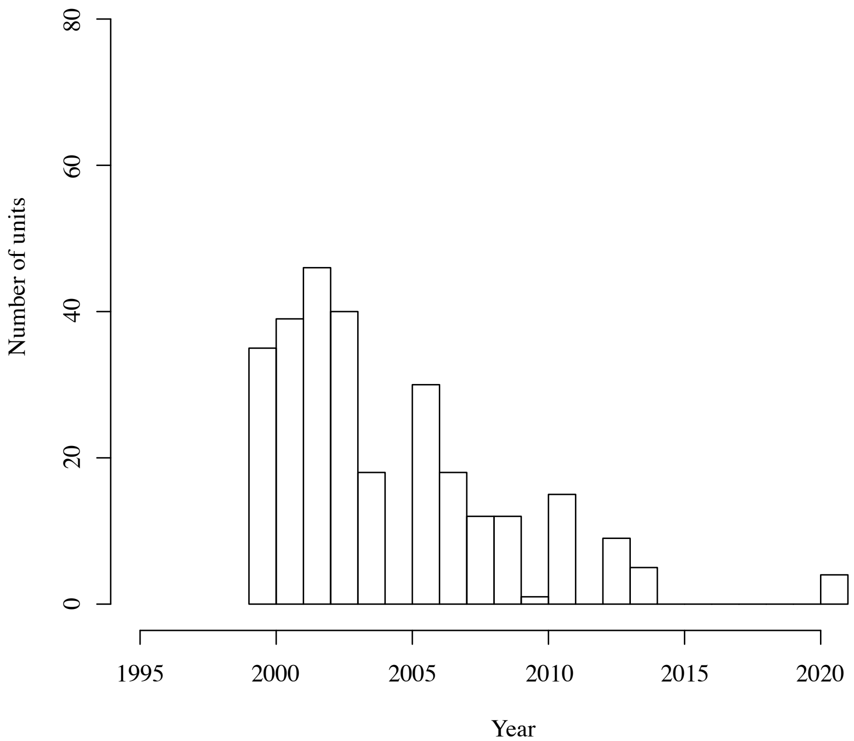


Figure 4.7: Unit development PROKON regenerative Energien eG, number of units commissioned per year. Source: COMETS database.

form in 2015. Recently, in 2020 four new units were commissioned (Fig. 4.7). The units have a minimum capacity of 600 kW and a maximum of 3600 kW. The histogram of turbine capacities is skewed towards lower values, with a median of 1500 kW. These capacities range well beneath today's turbine standards ranging between 2 and 6 MW (see Tab. 2.3). As the 20 year state remuneration of turbines commissioned in early 2000s is about to run out in the next years and the economical efficiency decreases, PROKON has to choose between re-powering and dismantling.

PROKON benefits from a professional structure within the entity, which was set up by the limited liability predecessor. The human capital, including know-how, knowledge and networks remained within PROKON throughout the change of legal form to a cooperative. In comparison to other wind cooperatives relying on voluntary work, the cooperatives' size allows PROKON to further employ professionals throughout the companies network. The cooperative is now benefiting from formerly acquired property rights and ownership of wind turbines, which were mostly commissioned pre-cooperative (Fig. 4.7). PROKON emphasizes as a historic benefit build trust throughout the company's history with partners and costumers, which contradicts the lost trust as a reason for insolvency. Last but not least, PROKON relies on the member shares as a resource and the financial backbone of the cooperative, restoring liquidity after insolvency.

Figure 4.8 details the current network of key partnerships of PROKON. The current business network is comprised of three managing directors (MD) and two chief officers (CxO). These persons build the junction to four legal entities, which are also active in the wind energy sector. In addition to their position at

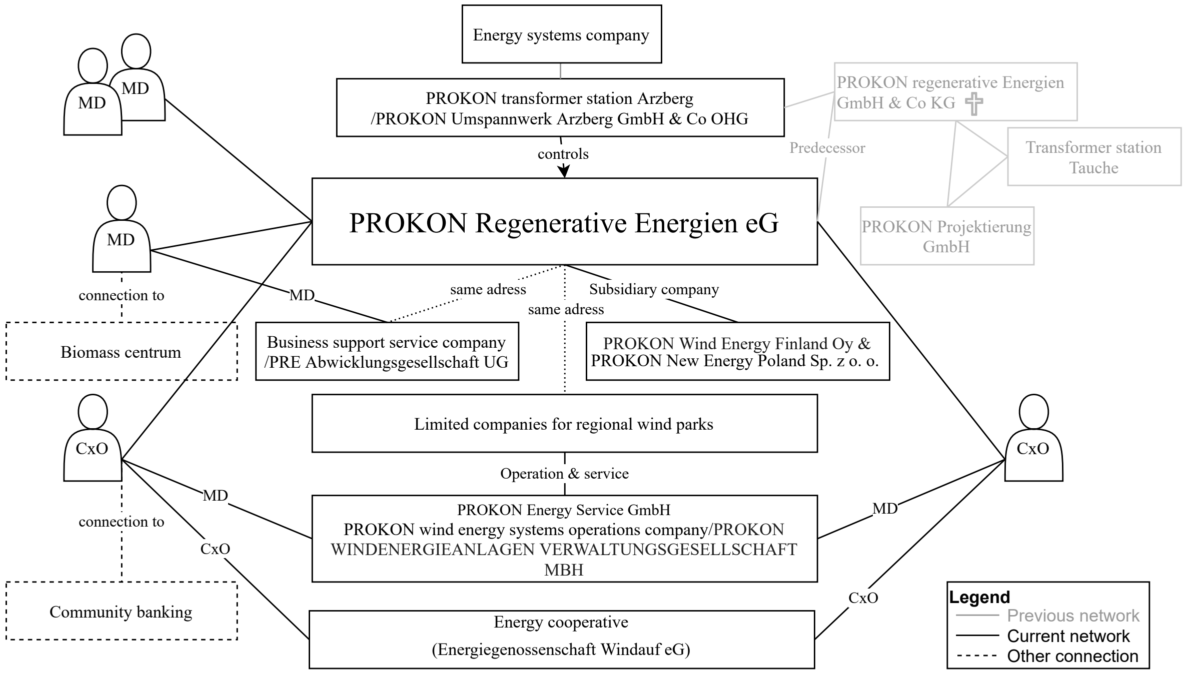


Figure 4.8: Business network of PROKON regenerative Energien eG, own revision based on North Data GmbH (2021) and webvalid GmbH (2021). Positions: Managing director (MD), Chief officer (CxO).

PROKON, the chief officers are managing directors of the PROKON subsidiary companies, PROKON wind energy service GmbH and PROKON wind energy operations company. They further are chief officers of the energy cooperative Windauf eG. The cooperative's address is shared with several limited companies erected for the operation of regional wind parks and one business support service company. Further subsidiary companies of PROKON in the wind sector are the transformer station Arzberg (68%), and internationally Wind Energy Finland (100%) and New Energy Poland (100%). The international subsidiaries are responsible for management and operation of the wind parks in their country.

With PROKON's service of electricity tariffs from local and supra-regional renewable energy facilities they are promoting transparency and provide access to green energy. For the customer base, this concept translates into a reduction of greenhouse gas emissions from their electricity consumption. PROKON is as well stabilizing the local economy in its region of origin, by providing jobs through the cooperative and their subsidiaries. It is arguable however, how much local value proposition the employment of owned subsidiaries provides to project areas. The cooperative promotes project partnerships with discounts on electricity tariffs for local municipalities or residents.

Since the foundation of the cooperative in July 2015, the number of members increased from 38024 to 39589 by 30.06.2020 (Figure 4.9). A member share can be bought for 50 EUR and the deposit can be extended in agreement with the board. Members receive in case of good business revenues a dividend on their share. The first years after the insolvency this was not realized, but as the cooperative was generating profit again in 2017 dividends to members were payed. Further benefits from the membership include for example a discount on home charging boxes

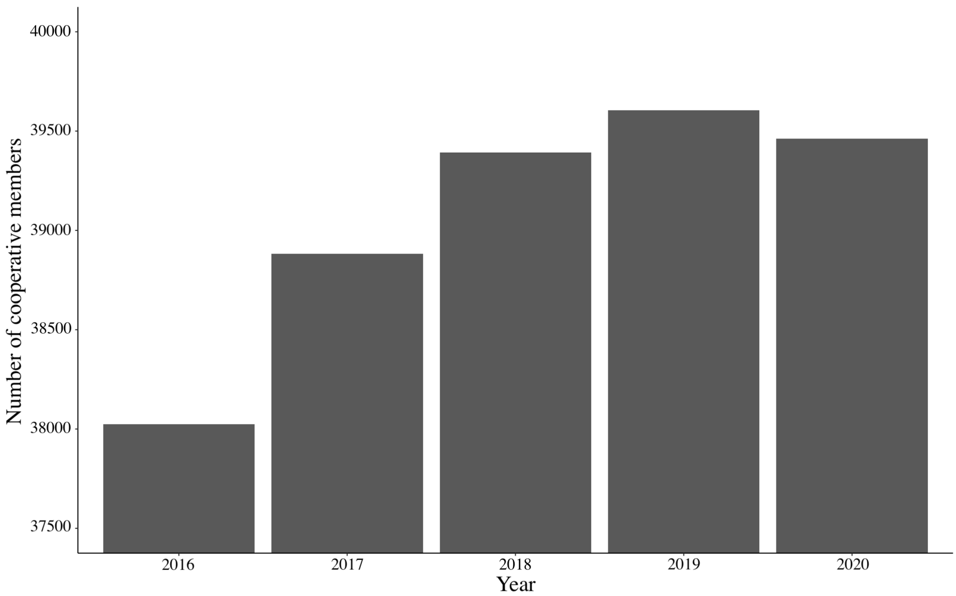


Figure 4.9: Member development PROKON regenerative Energien eG, number of members at 1st of January. Sourced from financial records (PROKON regenerative Energien eG, 2021).

for electric vehicles in cooperation with a commercial partner. The professional employees are another member benefit, as they handle member services and the realization of wind energy projects.

Customers of PROKON are mainly associated with the provided electricity tariffs for private households and commercial enterprises. This customer base and the member base do not fully overlap. Customers are not obliged to have a membership.

PROKON has to cope with expanses, arising from realization and operation of wind power plants. Furthermore, there are costs associated with the electricity trade as well as the license as an electricity supplier. Additionally, the cooperative has to operate a platform to offer their electricity to costumers. Customers and cooperative members need support and an administrative structure, adding on to the business costs.

Operated units from PROKON both fall under the categories of partly and full feed-in state remuneration, creating revenue. Another revenue stream from the applied business model is connected to electricity trade, selling or reselling own electricity within Germany.

4.3 Case 2: Energiegenossenschaft Starkenburg eG

The Energiegenossenschaft Starkenburg eG is a medium to large size cooperative and one example for a bottom-up citizen initiated project. Furthermore, the cooperative originates from the southern German Federal State Hessen. With now around 1000 members, the cooperative was able to invest and operate several wind turbines on its own. This stands in contrast to other smaller cooperatives, which are only shareholders of wind production units.

*Figure 4.10: Business model canvas Energiegenossenschaft Starkenburg eG, own figure based on Osterwalder et al. (2010) and Dilger, Konter and Voigt (2017). Overlapping categories are marked with *.*

On the 15.12.2010, the cooperative Energiegenossenschaft Starkenburg eG was founded by 13 citizens in the city Heppenheim. The aim of the cooperative is to provide value to the local community through financing renewable energy projects. The envisaged climate protection effort relies heavily on voluntary work.

The displayed business model canvas gives an overview of the value creation process of the cooperative (Fig. 4.10). In total, the cooperative owns or co-owns

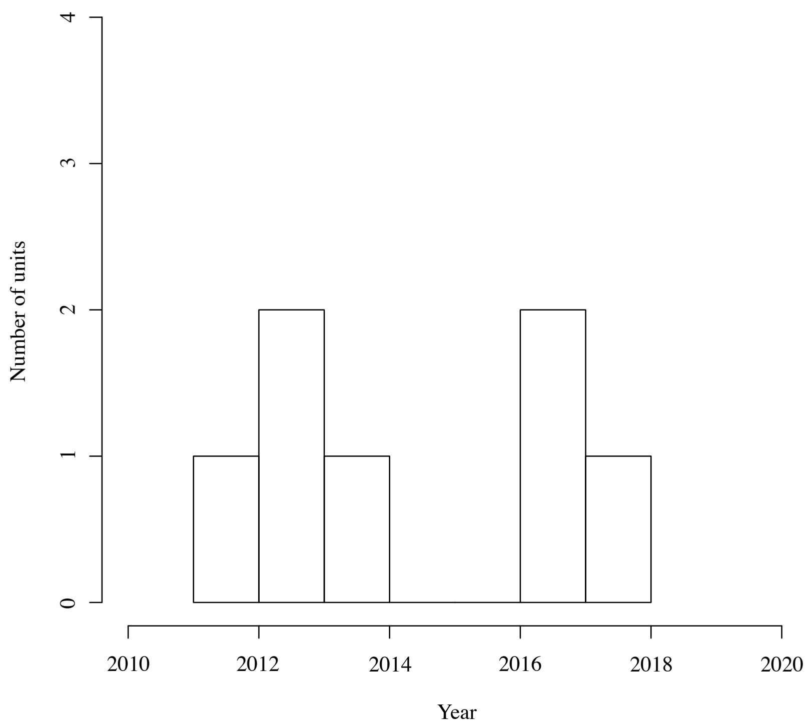


Figure 4.11: Unit development Energiegenossenschaft Starkenburg eG, number of projects commissioned per year. Source: COMETS database.

seven wind power production units. For three of them the shareholding size for the wind park is unclear. The two fully owned facilities are accounting for 4580 kW. In addition, the Energiegenossenschaft Starkenburg eG is a minority shareholder of two higher capacity onshore turbines with 4000 kW (10%) and 4200 kW (17%). The time frame of commissioning of the respective units is displayed in Fig. 4.11, which is correlated with the overall trend identified in Section 4.1.1.

Besides the wind energy engagement the Energiegenossenschaft Starkenburg eG is owning 31 regional, solar photo-voltaic projects (3.638 kWp). The systems are exclusively roof-mounted. In addition, the cooperative is connected to a biogas power plant and has one wood heat contract with a municipality. Furthermore, the portfolio contains five public charging points for e-mobility vehicles, and an electricity tariff is provided through the regional cooperative network Bürgerwerke eG. Noteworthy is that the cooperative has a partner project in Mali, which implemented a solar irrigation system.

On their website, the Energiegenossenschaft Starkenburg emphasizes that all projects are 100% financed by investments of citizens. The necessary financial investments for renewable energy projects are thus provided by their members through payment of membership shares and the granting of member project loans. This type of financing can not be considered common, as most other cooperatives are relying on bank loans, preferably from local cooperative banks (Klagge and Meister, 2018). For Energiegenossenschaft Starkenburg, their member-driven financing model might only be feasible, because of a large availability of private capital in the region, generated in the economically strong metropolitan area Rhein-Main. In addition to financial resources, renewable energy projects draw from internal know-how of management and members of the cooperative.

As displayed in Fig. 4.12, the cooperative Energiegenossenschaft Starkenburg eG is run by three chief officers. One of them is the managing director of EnergieSTARK GmbH, which unites the GmbHs for the owned wind parks and the biogas facility. The wind park entities and the umbrella limited liability company share the same address with the cooperative. The establishment of limited liability companies sharing the cooperative's address to run wind production units is commonly observed throughout the whole data set (Section 4.4). These companies provide a suitable structure to allow a shared holding with municipalities, other cooperatives or commercial partners. On their website the Energiegenossenschaft Starkenburg eG emphasize their partnership with other energy cooperatives and local project partners like municipalities and counties. Furthermore, the cooperative will support other emerging energy cooperative projects.

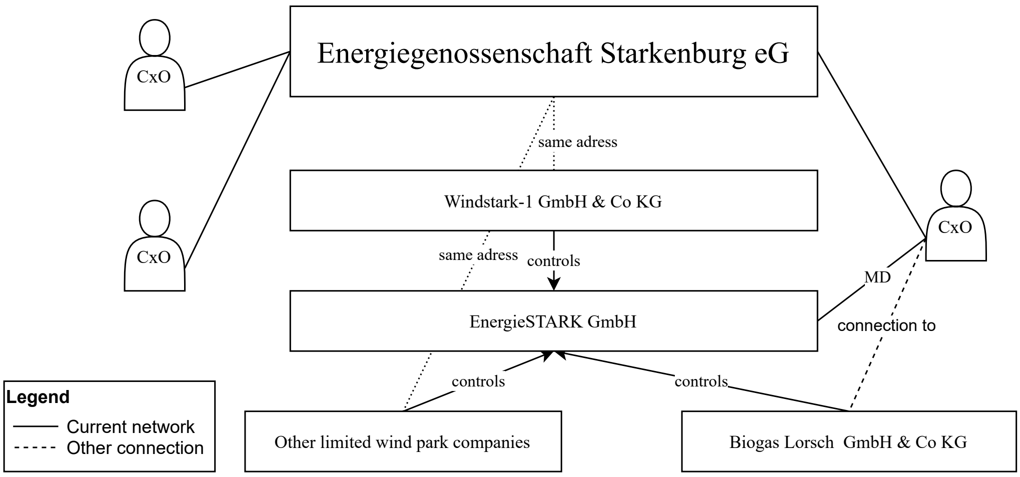


Figure 4.12: Business network of Energiegenossenschaft Starkenburg eG, own revision based on North Data GmbH (2021) and webvalid GmbH (2021). Positions: Managing director (MD), Chief officer (CxO).

By financing regional, renewable energy projects the cooperative promotes renewable energy services and partly upgrades the accommodating infrastructure for such services (Section 2.2). In addition, Energiegenossenschaft Starkenburg eG provides access to locally produced electricity through Bürgerwerke eG. The services of electricity supply platforms, like Bürgerwerke eG, are often used by cooperatives to avoid obtaining their own supplier license. PROKON regenerative Energien eG in contrast is large enough to operate and sale their produced electricity through their own platform (Section 4.2).

The membership in Energiegenossenschaft Starkenburg eG is open to all legal forms with no regional requirements. Two membership shares à 100 EUR have to be bought and an additional project loan of 1800 EUR has to be provided to become a cooperative member. Currently, waiting lists are used, because additional members are only permitted with new projects to guarantee economical sustainability. Especially for small and medium-sized cooperatives need to balance of the number of members and the number of projects, in order to be economically successful. Therefore, member admission stops are a commonly used tool in times of

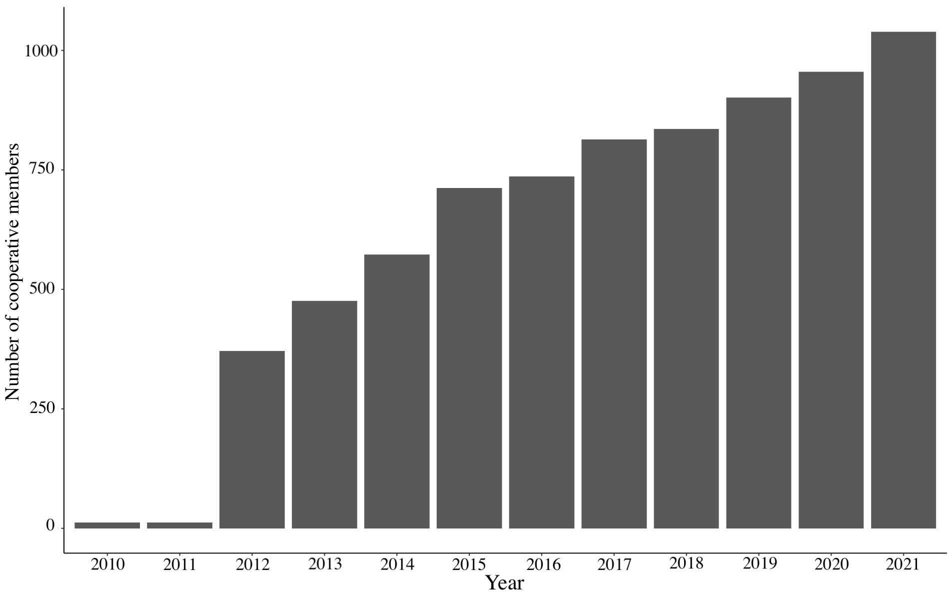


Figure 4.13: Member development Energiegenossenschaft Starkenburg eG, number of members at 1st of January. Sourced from financial records (Bundesanzeiger Verlag, 2021c).

project scarcity. Over the course of their existence, member records show though a steady increase (Fig. 4.13). The high overall financial commitment for members of Energiegenossenschaft Starkenburg mirrors the capital intensity of wind power projects (see Section 2.1.1). The acquisition of necessary capital, especially for realizing own cooperative wind power projects, is posing a hurdle for wind energy cooperatives. In general, solutions for the necessary capital acquisition are either high membership commitments, as shown in this case study, or a bigger member base with smaller per capita investments. The former solution might be more feasible with stricter regional boundaries, restricting the availability of members. The latter solution is in contrast more inclusive to different types of member groups, but might come with higher general administrative costs to support the large amount of members.

Costumers of the cooperative are members as well as electricity tariff customers. Furthermore, a customer relationship is obtained with property owners (e.g., leasing agreements). The observation of overlap between members and customers is a typical feature of cooperative business models (c.f. Dilger, Konter and Voigt, 2017).

As the cooperative is active in planning, realization and operation of renewable power plants, they have to cope with the costs associated with their activities. The use of the platform Bürgerwerke eG to trade produced electricity adds shared cooperative costs as well. Apart from this, the cooperative has to cover business management costs. It has to be noted, that the cooperative operates on the basis of voluntary work of their members, reducing costs for labour. This voluntary work contrasts with the otherwise professional, business-like structure of PROKON regenerative Energien eG.

The revenue associated with the wind power production is divided into state remuneration and revenues from electricity trade. Furthermore, the same revenue streams are realized for the solar PV power plants. In addition, charges from contracting and consulting activities complement the cooperative earnings.

4.4 Stylized wind cooperative business models

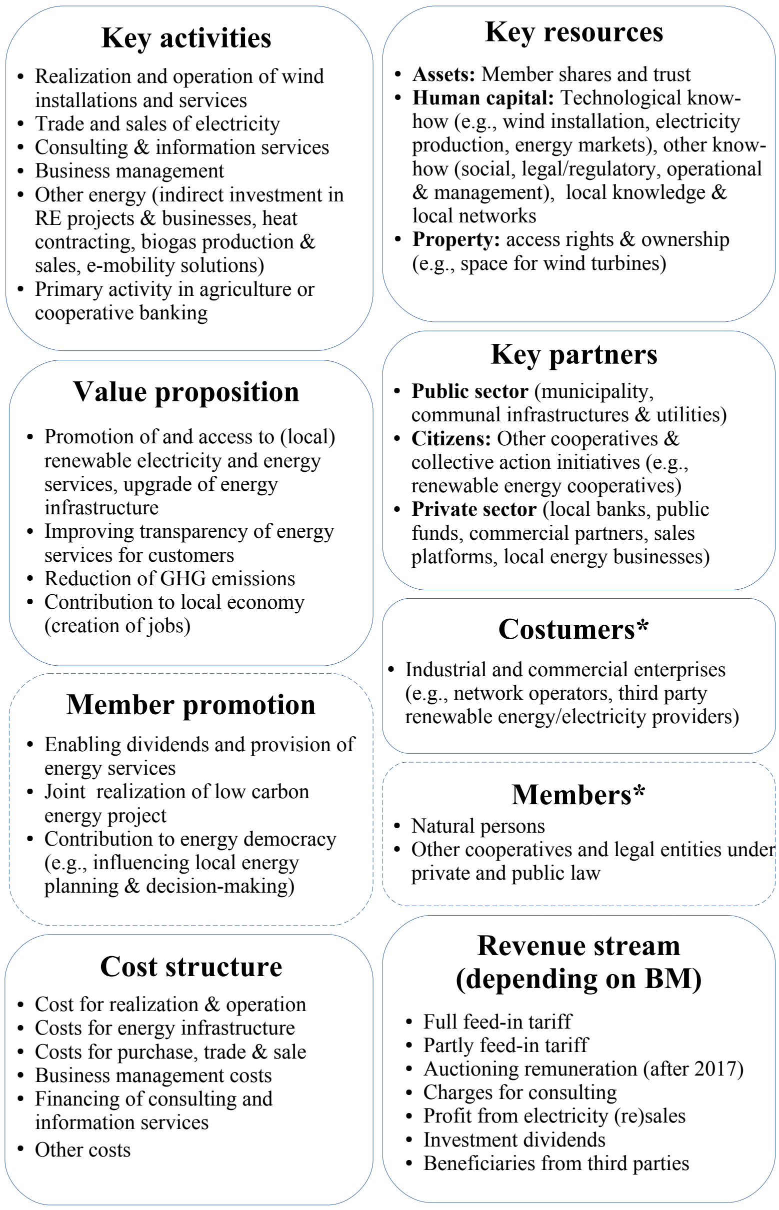


*Figure 4.14: Stylized business model canvas for wind cooperatives in Germany, based on the structure of Osterwalder et al. (2010) and Dilger, Konter and Voigt (2017). Overlapping categories are marked with *.*

Besides operating and realizing wind projects, the key activities of cooperatives in the wind sector are the production of other renewable energies (highest share in solar photo-voltaic) and electricity trade (e.g., offering green electricity tariff). Activities in connection to agriculture and banking of cooperatives only play a minor role in the dataset. But if observed, they are the cooperative's primary field of business. Subsequently, they create the financial backbone for wind power investments. As electricity producers, energy cooperatives have to deal with management and operation of wind power plants. Furthermore, some investigated cooperatives were additionally active in the mobility sector, heat sector and consulting, guided by a vision of sustainability.

The key resources of German wind cooperatives can be summarized as financial assets, human capital and property. Financial assets for wind projects are mostly generated through investments into membership shares. Another foundation cooperative activity builds on is trust, both in regard to their own members and other project actors. Human capital refers to the know-how and knowledge provided by the management and cooperative members. Property rights are usually obtained through agreements with land owners and are essential for starting wind power projects.

Major partners for the conduction of wind energy projects are the public sector, other citizen-led initiatives, cooperatives, and the private investment sector (e.g., banks, commercial partners). Together they act as a network to secure funding as well as suitable project sites. In case of electricity sales, electricity suppliers such as sales platforms are major partners (c.f. Ehrtmann, Holstenkamp and Becker, 2021).

The involvement in electricity retail requires a permission as an electricity supplier. Cooperatives avoid the costly obtainment of this permission by partnering with suppliers. The most prominent examples are naturstrom vor ort GmbH, a subsidiary company of the Naturstrom AG as a private partner and the cooperative umbrella organisation Bürgerwerke eG (Ehrtmann, Holstenkamp and Becker, 2021). The Bürgerwerke eG was founded by several cooperatives active in the energy sector to create the opportunity to be active in electricity trade. Both organisations provide a platform for electricity retail to promote local and renewable energy production by freeing the cooperative market actors from the burden of regulations and obligations of a licensed electricity supplier.

The statutes of the cooperatives usually contain a clause that natural persons and legal entities are authorized to join them as a member. Nevertheless, the investment in wind projects or their associated cooperatives has typically regional restrictions to promote the local value proposition. As a member promotion, cooperatives offer flexible dividends of the investments depending on their economic situation, and possible discounts programs in regard to electricity (e.g., e-mobility wall box for charging). Furthermore, cooperatives offer the possibility for members to actively participate in energy democracy and thus establish a low carbon energy project in their region.

The customer structure is not distinctively differentiated from the members, as members are usually customers with regard to the produced electricity and services as well. In addition, commercial or industrial enterprises are customers of renewable electricity from cooperatives. Typical companies in this regard are network operators and electricity providers.

Cooperatives provide a local value proposition in form of produced renewable electricity, connected services, an upgrading of the electricity infrastructure and the creation of jobs. One benefit, that is not distinctly local, is the general contribution to the reduction of greenhouse gas emissions of electricity production.

Project planning, realization, operation and maintenance are typical cost categories connected to the commissioning and operation of a cooperative wind power plant. Furthermore, since 2017, also costs for the participation in the tendering procedure for wind capacities have to be covered as well (Section 2.2). Last but not least, the operative costs for the day-to-day business have to be covered.

Revenues of energy cooperatives strongly depend on the applied business model. The business models can be based on state support schemes, consultancy services, investment returns, beneficiaries from third parties or a combination of the before aforementioned. The most abundant type of state remuneration in the data set is full feed-in (34%). Only 5 units were identified as partly feed-in, using for example the other part of the produced electricity for auto-consumption.

4.5 Identified barriers and enablers

Enablers	Barriers
Strong local partnerships and networks	High investment sums/financial risks
Favourable policies: Feed-in tariff	Unfavourable policies: Tendering
Support of umbrella organisations	Regional boundaries
Broad activity portfolio	Long permission procedures
Expansion of cooperative	Dependence on voluntary work
Innovations through professional management	Opposing citizen movements
	Internal conflicts (e.g., ethical considerations)
	Increasing complexity of energy market

Table 4.2: Identified barriers and enablers for wind cooperatives based on literature review and statistical analysis.

Table 4.2 shows the identified barriers and enablers based on the literature, the qualitative review, and the numerical analysis. One barrier to investments in wind power plants are the high upfront costs (see Section 2.1.1). A significant number of the cooperatives are not able to bear the financial costs of a project on their own or they are not willing to cope with the risks alone. In the dataset, 26% of the projects are either identified as shareholdings or unclear shareholding. This shows that the financing of new projects often depends on partnerships. If project partners or projects on the cooperative market are scarce, the investment volumes pose a barrier for cooperative engagement in wind power.

The recently introduced tendering scheme shows a negative effects on the newly commissioned, cooperative wind power capacity. This indicates that the support scheme is acting as a barrier to new investments. Anecdotal evidence from the investigation of websites shows that cooperatives frequently used the fact, that they were still able to profit from the feed-in scheme before 2017, as an argument to sell wind projects. This in turn, identifies the former feed-in scheme as an enabler for cooperative engagement in the wind energy sector.

The regional focus of most wind energy cooperatives can be viewed as a barrier since it is restricting the available resources (members and property). Although, examples like Energiegenossenschaft Starkenburg show that member recruiting seems to be a minor problem, access to suitable project property is restricted by regional zoning plans and thus remains mainly scarce. Hereby, significant differences throughout the different Federal States in legal regulations regarding wind power also lead to different resource availability. Closely connected to the financial investment are suitable project partners, which can enable or, in absence of them, prevent cooperative wind projects from realization. Those partnerships are usually found to be among cooperatives or with municipal organs.

Medium and small-size cooperatives heavily depend on voluntary work of their members and management. A classical example for this is the case study of Energiegenossenschaft Starkenburg eG, which manages seven wind projects solely based on their members. The dependence on voluntary work becomes a problem for cooperatives, when they lack time and knowledge as key resources. The knowledge resources are mostly acquired through the founders and management of the cooperatives (DGRV, 2019). As nonprofessionals, citizens are challenged by both, a higher technical and a higher market complexity (see Chapter 2). The complexity of the market increased with the introduction of tendering, opening the market for competition. Furthermore, tendering introduced an additional bureaucratic burden to citizen wind project realization (Lundberg, 2019).

Internal and external conflicts of cooperatives are barriers of their engagement. Externally, cooperative wind projects receive head winds from opposing citizen initiatives. A prominent legal structure to organize opposition to wind energy projects is the association (see Section 4.1.2). Among other things, the wind opposition utilizes law suits to prolong the permission procedures. The German Environmental Agency (UBA, 2021a) judges these long approval procedures to be unnecessary and characterizes them as a barrier not only for the citizen-led wind energy, but for the whole wind energy sector. In addition to external conflicts, cooperatives also face internal challenges. Examples are ethical debates about business model innovations, attempting to balance a cooperative's moral and economic principles (Herbes et al., 2017).

Expansion of cooperatives can provide financial capital for the high investment sums connected to wind power production. In addition, cooperatives benefit from growth strategies as they provide the opportunity to increase economic leverage on the market (e.g., economies of scale) (c.f. Wassermann, Reeg and Nienhaus, 2015). The generated resources from cooperative growth can be used to invest in salaried management positions. A professional management is deemed to foster business model innovations and needed to react to future market changes (Herbes et al., 2017).

A broad portfolio of activities enables cooperative activity, because it diversifies risks connected to renewable energy production. Diverse portfolios decrease the total dependence of the cooperatives on technical and legal developments from a single technology or service. Frequent activities, found in addition to wind power production, are solar PV and electricity trade.

Chapter 5

The future of cooperatives in the wind sector

5.1 Citizen-led wind energy

Through the investigation of this master thesis, it could be shown that cooperative wind production units are spread across the country and wind cooperatives' headquarters are mainly located in the southern parts of Germany. The first observation leads to the impression, that the cooperative engagement is not predominantly determined by the wind yield potential at the respective location. Technological advancement and the favourable state support with fixed feed-in tariffs for renewable energies drove wind development supra-regional (Chapter 2).

Furthermore, this master thesis provides statistical evidence that state support with fixed feed-in remuneration for onshore wind power enabled citizen-led initiatives to invest. In addition, the eventually introduced tendering support schemes can be regarded as a major barrier for citizen activity. The investigation of wind cooperatives' activity portfolios revealed a diversity of engagement in other renewable energy technologies and electricity sales. Overall, cooperative activities are found to be dependent on the size and involvement of the cooperative member base, as well as on the availability of suitable commercial, citizen-led or municipal partners to enable the citizen engagement.

In the described data set, the typical regional or national bounding of cooperatives for value proposition is indicated by a dominant employment of wind turbines from German producers. The only international competitor with a significant share on the cooperative market is the Danish company Vestas Wind Systems A/S, which is in regional proximity and was leading in the early development phases of wind turbines. The higher share of German producers could be explained by three different motives. First, practical considerations could lead to the conclusion that the German producer group can provide a better service structure within Germany. Secondly, by the time of realizing most of the citizen-led wind projects, German producers led the wind turbine market. Third, the cooperatives favor to support national manufacturers over international competitors in accordance with their principles.

However, the apparent regional divide of cooperative headquarters and the location of production units questions the proposed focus on regional value proposition. Furthermore, the cooperative's advantage in counteracting NIMBY effects may be doubted as wind turbines are usually not actually placed in the backyards of the investing citizens. Consequently, the generated profits are also not realized regionally. Nonetheless, the finding that more wind cooperatives are located in the southern states is consistent with Punt et al. (2021), who report a generally higher founding rate of energy cooperatives in the southern federal states Bavaria and Baden-Württemberg. Their model finds a positive correlation between already existing cooperatives in other industries and the foundation rate of renewable energy cooperatives. They attribute the found effect to legitimacy spillover effects from other cooperative businesses. Furthermore, the total rate of new energy cooperative foundations was related to policy frameworks (e.g., Renewable Energy Sources Act) and market conditions (e.g., electricity price).

On the one hand, cooperative wind power development is highly dependent on political support schemes (see Chapter 2). On the other hand, political success in the German energy transition requires investments of private capital in renewable energy technologies (Ohlhorst, 2016). This private capital is provided through commercial investors and cooperatives. So, the cooperatives are acting as an important investment vehicle to generate private capital for the energy transition. Thus, a mutual dependence of politics and cooperative activity exists. Wierling et al. (2018) state that guaranteed feed-in tariffs are an especially effective instrument to facilitate successful energy cooperative business models.

The data used in this thesis shows a peak of foundations of wind cooperatives in 2012 with a three year long plateau after 2013 before it declined to the current level of foundations. Klagge and Meister (2018) find a similar boom of the in the entire cooperative sector in Germany in 2011 and a strong decline of foundations in 2014. The plateau was not visible in Klagge and Meister's dataset since their data was only spanning until 2015. As Klagge and Meister (2018) and Wierling et al. (2018) suggest, the declines can be attributed to the amendments of the Renewable Energy Sources Act in 2014 and 2017. Firstly, announcing the support scheme change to tendering in 2014 and then secondly executing the first auctions for wind power in spring 2017.

The data analysis revealed a diverse activity portfolio of cooperatives in the wind energy sector, typically combined with additional engagement in solar PV production. In contrast to wind production, cooperative PV recently showed an increase in new capacities (Wierling et al., n.d.). This trend is observed despite the remuneration change to tendering (2014). This demonstrates that cooperatives react differently to changes in the energy market or changes in the support frameworks depending on the type of energy technology, because of differences in associated investment costs and risks. Greater diversification of activities is thus expected to improve the sustainability of energy cooperatives in the market (Klagge and Meister, 2018; Wierling et al., 2018).

Since the introduction of tendering, electricity markets are competitive and include scale effects for all actors. Economies of scale materialise in discounts for the realization and maintenance of wind production units, discount rates on bulk purchases for cooperative networks or increased cost efficiency through outsourcing. Outsourcing is, for example, observed in the PROKON regenerative Energien eG case study, where the size of the cooperative enables them to out-source maintenance activities to subsidiary companies. Klagge and Meister (2018) argue that as economies of scale are becoming more important with an increasing openness of the market to competition. In consequence, it is anticipated that energy cooperatives will enact growth strategies in the future.

Key resources of cooperatives, both of financial and cognitive nature, are rooted in competences of founders, members and management (DGRV, 2019). The majority of energy cooperatives lack financial resources, which limits their possibilities to employ professional management and thus they need to heavily rely on voluntary work (Herbes et al., 2017). An exception here are the biggest energy cooperatives in the investigated dataset, namely PROKON regenerative Energien eG and Greenpeace energy eG. The voluntary work of cooperative members is limited in time, through their cognitive abilities and prior experience in the energy sector. The newly introduced tendering support scheme increases complexity of the investment process in wind energy production as well as requires the assignment of additional workload for the bidding process (Lundberg, 2019). Lundberg (2019) notes that this disproportionally puts a higher burden on small actors with scarce resources. Generally, cooperatives are considered as locally focused with limited power and resources (Bauwens, Gotchev and Holstenkamp, 2016).

Furthermore, the discussion about moral principles in energy cooperatives leads to ethical concerns in the business innovation process (Herbes et al., 2017). When the members, as a sovereign in the democratic structure, decide that a business model innovation approach of their management is not in line with moral principles, they can stop the development by vote in the general assembly. This dependence of the management on the members' goodwill leads also to more formal voting processes than necessary (Herbes et al., 2017) and in consequence can slow down the decision making processes.

At the same time the restrains of the regional focus, local rooting and knowledge, are the most valuable resource energy cooperatives can market to business partners (Herbes et al., 2017). The local network provides the opportunity for commercial partners to connect with citizens to increase local acceptance for their wind project. Furthermore, having cooperatives as partners provide the opportunity to create a local value proposition through citizen shareholding. Thus, if financial benefits of local citizens are tied to the project success, this creates strong incentives for the local citizens to accept local wind power production. Both, the case study of Energiegenossenschaft Starkenburg eG and the general business model investigation, revealed a dependence of cooperative activity on suitable project partners (see also DGRV, 2019). The inherently higher risks of a market-based support schemes in comparison to fixed feed-in remuneration calls for partnerships to diversify cooperative investment risks. The partnerships are bundling resources and lower investment and planning risks (Silva and Klagge, 2018). Prominent partners for cooperatives are aggregators (umbrella organisations), (cooperative) banks, housing cooperatives, commercial energy suppliers and municipal utilities (Herbes et al., 2017). Especially, commercial partnerships can help by providing the necessary risk capital for the acquisition of land and other up-front investments for wind power production (c.f. Bauwens, Gotchev and Holstenkamp, 2016). The value energy cooperatives are offering in these partnerships is the provision of a higher acceptance among citizens and local network structures for wind projects. Herbes et al. (2017) therefore view partnerships as a probable solution to upcoming challenges on the cooperative energy market.

Barriers for partnerships on the one hand originate from within the cooperative structure and on the other hand from the outside perception of other market actors. Commercial market actors might not consider or even refuse to partner with cooperatives, because technically they are competing on the same market (Herbes et al., 2017). A contrasting example can be found in the commercial energy supplier EnBW, who seeks citizen partnerships in wind energy to open up new customers for their business. Herbes et al. (2017) describe in addition to the aforementioned concerns, that ethical concerns by cooperative members and the management might form a barrier for the acceptance of business innovations, including business partnerships. They name high revenues or the maintenance of activities not in line with the intention of the energy transition as ethical reasons for opposition. Nevertheless, Herbes et al. (2017) state that according to a survey from 2014 already 40% of regional and 60% of supra-regional energy cooperatives work with partners under collaborative agreements.

In addition to cooperative activity, this thesis also investigates the activity of associations in the German wind energy sector. The findings on associations show, that they play an important role, mainly by offering communication platforms for wind power opponents. This type of citizen-led engagement is not as frequently mentioned or investigated as cooperative activity in the German energy transition, but might play a crucial role in the social debate about onshore wind power.

5.2 Identified barriers and enablers

Enablers		Barriers	
Favourable policies: Feed-in tariff	++	Unfavorable policies: Tendering	−−
Strong local partnerships	++	Lack of resources (e.g., financial capital)	−−
Strong regional ties	++	Regional boundaries	−
Broad activity portfolio	+		
Expansion of cooperative	+		

Table 5.1: Rating of identified barriers and enablers of wind cooperatives on a subjective scale (++/+ and −−/−).

Table 5.1 summarizes the identified barriers and enablers of citizen-led wind energy projects and rates entries on a subjective scale according to their effect. One of the main findings of this master thesis is that it provides evidence for reliance of cooperative wind power productions on political support schemes. The clear correlation of the decline in commissioned cooperative wind power units coinciding with the change in the state support schemes indicates that the tendering scheme is acting as a barrier for cooperative engagement. This affects not only the citizen-led engagement forms negatively, but the general trend in bids for onshore wind power capacities also shows a decline (Bundesnetzagentur, 2021e). It was overwhelmingly the former feed-in scheme (Section 2.2), consisting of less bureaucratic and risk hurdles for cooperatives that enabled citizen-led activities in onshore wind projects in Germany. This finding matches former research, that found feed-in tariffs to be a successful tool to promote citizen-led activity (Punt et al., 2021; Wierling et al., 2018).

The results of two case studies performed in this thesis can be summarized as follows. The regional focus of cooperatives, exemplified by the case of Energiegenossenschaft Starkenburg eG has to be discussed in a twofold way, both functioning as an enabler and a (future) barrier. On the one hand, regional networks create opportunities for initial cooperative energy projects locally. Herbes et al. (2017) find, that investments outside the region tend to be criticised by cooperative members, because they are not perceived as being in accordance with the cooperative's local roots. On the other hand, restricting activities to a narrow regional area acts as a barrier to expansion of cooperatives (Herbes et al., 2017). Regionality limits the available resources of an energy cooperative, both in terms of suitable sites and in terms of human or financial capital. Nevertheless, diversification of activities in the energy sector, expansion of activities to a supra-regional or perhaps international level are seen as possibilities for cooperative business model innovations. Such innovation has the potential to create new opportunities to counteract a lack of resources, namely available space for wind energy production and financial assets from members (Herbes et al., 2017). An example for a wide spread cooperative structure is the case study of PROKON regenerative Energien eG. However, the case fails to be regarded as a blueprint, because of its descent from a standard commercial enterprise. This origin already provided the cooperative with an international focus.

With regard to resources, finding new members seems to be a minor challenge for cooperatives. For example Energiegenossenschaft Starkenburg eG has waiting lists for memberships. Yet, economical cooperative management is only possible by balancing membership size with the available investment size. In the absence of suitable projects or project partnerships, this creates an obstacle to the omission of new members. The size of the project portfolio is further governing the financial ability to employ professional management, which in turn has the potential to accelerate business model innovations (Herbes et al., 2017).

In the recent amendment of the Renewable Energy Sources Act 2021 (c.f. Tab. 2.5), the federal government promises financial benefits for municipalities, that successfully realize wind power productions within their territories. This measure may increase municipal activities with regard to zoning and approval of new wind power plants, or even foster own engagement in wind projects. Consequently, the already existing partnerships with municipalities and the regional ties of energy cooperatives create opportunities for citizen-led wind energy projects (c.f. Drewing and Glanz, 2020). Today, already existing partnerships with electricity suppliers, like Naturstrom AG and Bürgerwerke eG, give energy cooperatives the opportunity to engage in electricity trade with regionally produced electricity from renewable energies (Ehrtmann, Holstenkamp and Becker, 2021). Those partnerships or umbrella cooperatives are networks, that can help to realize economies of scale for the smaller, regional energy cooperatives, also enabling them to diversify and evolve sustainably on the energy market.

5.3 Prospects for the future

The government declares the change in support mechanism as a step towards less regulated renewable energy markets and a more sustainable open market (post support era) (BMWi, 2021d). The observed decline in the wind energy sector, both in terms of cooperative capacities and foundations, suggests that the system is currently not self-sustaining, at least for citizen-led actors. Recent research from Herbes et al. (2020) found, that market-based approaches are not effective in replacing state-led support to foster the expansion of renewable electricity production. Thus, consumer demand is not sufficient to support the development of renewable electricity production yet. The authors base their findings on the analysis of green electricity tariffs in four European countries, including Germany. These electricity tariffs are mostly based on hydropower, which has low growth rates in Europe. Therefore, the green electricity can not be considered sustainable.

A glance at Denmark's history as a pioneer country for citizen-led onshore wind energy in the late 20th century might be able to give a hint and provide a perspective for the future of cooperative wind power in Germany. Favourable market conditions connected to feed-in guarantees and tariffs resulted in a strong rise of cooperative wind activity until 2002 in Denmark (Wierling et al., 2018). A political shift in 2002 caused a break of this development and lead to a phase-out of feed-in tariffs for wind energy production. This left market actors subject to market competition. The authors find that after this break cooperative activity was inferior to their commercial competition and in consequence declined heavily. German projects might share the same fate in the future, unless suitable, political support schemes for citizen-led projects are enacted.

Amongst the research community, business model innovations that employ diversification and extension strategies are considered as possible pathways to prevent developments similar to the Danish example (e.g. Bauwens, Gotchev and Holstenkamp, 2016; Herbes et al., 2017; Wierling et al., 2018). When successful innovation is not resisted by internal or external barriers (c.f. Herbes et al., 2017), opportunities for continued cooperative engagement in wind power production arise.

Last but not least, future cooperative and citizen-led projects depend heavily on the political support schemes, that create financial securities for investments. Thus, the development of laws, like the Renewable Energy Source Act, is greatly influencing the cooperative future on the German energy market. Furthermore, the future development of onshore wind energy, more precisely the whole energy transition process, rests upon private financial funding and social acceptance to succeed. Both solutions of those key problems for future success might be united in the legal vehicle of the energy cooperative.

Chapter 6

Conclusion and limitations

This master thesis concludes by returning back to the research questions:

- What qualitative and quantitative statements can be made about the current state of citizen-led projects in the German wind energy sector?
- What are the prospects for citizen-led initiatives in the wind sector, by identifying barriers and enablers?

By providing numerous insights into citizen-led activity in the German wind energy sector, this thesis is presenting evidence of citizen engagement in the energy transition. The qualitative and quantitative explorations result in a cooperative business model for the wind energy sector. This stylized business model analyses 9 categories (Key activities, key resources, key partners, value proposition, costumers, members, member promotion, revenue stream, cost structure). It becomes evident that the cooperatives are heavily dependent on their cooperative members, strong partnerships and favourable policy frameworks. Moreover, wind cooperatives engage in diverse activities across the wind energy sector and other sectors. Solar PV power production and electricity trade are very prominent examples. Returning to the first research question, 136 initiatives with 597 wind projects, and 1.9 GW installed capacities are active in the German wind energy sector (Section 4.1.1). In comparison to the total installed onshore wind power capacity in Germany (54.4 GW), citizen-led initiatives are owning around 3.5%.

In a next step I looked into the prospects of citizen-led initiatives by identifying barriers and enablers. It is the policy frameworks, first and foremost, that shape the German energy market. Especially, the Renewable Energy Sources Act with related legislation is fundamental for citizen-led activity (Section 2.2). Thus, the future development of the legislative framework will influence significantly the development of citizen-led initiatives significantly.

Since most of the cooperatives are regionally focused and rooted, the future of those citizen-led businesses depends on their ability to extend their activities and their member base. Being able to do so helps the cooperatives to cope with new market forces and regulatory risks posed by increasingly open energy markets. Partnerships with other cooperatives, public actors and/or commercial actors might be the main solution to diversify market risks in future onshore wind energy production. This master thesis has shown by the example of cooperatives, that citizen-led initiatives in the wind sector play a major role in the energy transition process.

Very few cooperatives are large-scale and operate internationally. One example is PROKON regenerative Energien eG, which has been studied in this thesis. Cooperatives such as PROKON have the potential to impact and shape the energy markets beyond Germany on an European level.

The second case study carried out, focused on a typical, mid-size cooperative (Energiegenossenschaft Starkenburg eG). Their wind energy activity follows the main trends in the citizen-sector and shows in particular the capital and resource intensity of onshore wind. The main insights are that regionally focused cooperatives depend on strong partnerships to realize wind power projects and have to diversify their activity portfolio to effectively use all available resources in their confined area.

All together, the analysis reveals the following barriers and enablers: Favourable political support schemes, strong project partnerships and local networks, unfavourable political support schemes, opposing citizen movements, internal conflicts, high investment risk, regional boundaries, and an increasing complexity of the energy market.

In conclusion, the citizen-led wind energy future strongly depends on favourable policy frameworks, determining the risks and complexity for citizen energy market engagement. Table 6.1 shows a full overview of the most important findings of the master thesis and condenses them into three take-home messages.

This master thesis, nevertheless, has limitations. This thesis has focused mainly on cooperatives and has left other forms of citizen engagement out. Despite the importance of limited liability companies for citizen-led wind projects (Holstenkamp and Kahla, 2016), the scope of this master thesis did not allow for an in depth structural analysis of limited liability companies in the wind energy sector. It is subject to future research to determine further the role of limited liability companies and associations as vehicles for citizen-led onshore wind in Germany.

Even though the process of search and collection of data was conducted in a thoughtful way, there still might be concerns regarding the process. Data issues connected to the search process, differences in data quality among the various sources and a potential bias regarding the choice of case studies is discussed in more detail in the following. The data search process was initiated through the Core Energy Market Registry. This may have led to a bias in the data set, because primarily major cooperative shareholders or owners were found. In turn, this bias would lead to small cooperatives falling through the cracks of the search. However, this limitation is considered to be small since cross references were already made during prior investigations of German solar PV cooperatives in the COMETS database.

Differences in data quality and quantity throughout the data set provided for example a limited resolution for cooperative projects as single units or wind parks. This limited the possibility to statistically investigate developments of wind production unit characteristics, such as capacity development or spatial correlations with wind yield potentials.

An inherent limit of the case study approach is a lack of generalizability, be-

Posed questions	Found answer	Take-home message
What are the quantitative and qualitative insights?	Statistics: 136 citizen-led initiatives with 597 wind projects (1.9 GW); decline of commissioned citizen capacity; headquarters of citizen initiatives predominantly in southern Germany; predominantly one wind project per cooperative Case studies: Diverse activity portfolios; high investment sums for wind projects	Citizen engagement strongly depends on favourable policies and the over-regional investments of cooperatives question their counteraction of NIMBY.
What are barriers and enablers for citizens activity?	Literature: Internal barriers (cognitive, ethical); external barriers (unfavourable policies, long permission procedures); enablers (local partnerships, support of umbrella organisations, broad activity portfolio, favourable policies, professional management) Statistics: Barriers (tendering); enablers (feed-in tariffs) Website review: Increasing market complexity; long permission procedures Case studies: Dependence on strong partnerships for project realization; members as a key resource for activity	Market-based tendering support schemes put a disproportionally high burden on energy cooperatives (lack of resources, lack of professional expertise) compared to bigger private actors.
What are future prospects for citizen-led in Germany?	Literature: Business model innovations, growth strategies; diversification of activities Case studies: Diversification and expansion to cope with future market challenges	The future of citizen-led wind energy depends on successful implementation of growth and diversification strategies.

Table 6.1: Concluding overview of the research questions.

cause any derivations are potentially based on the specific and individual characteristics of the chosen examples. The choice of case studies might under represent smaller wind cooperatives, which are not owning own wind production facilities, but shareholdings.

6.1 Outlook

Further research can build on this master thesis by extending the initial description of cooperative assets in more detail by investigating financial reports in depth. This could be related to the total cost of the German energy transition and guide political decisions. In addition, the described business models set a baseline for further research about cooperative business model innovations and future prospects on the market. An in-depth comparison with commercial and private actors on the German wind energy market may yield the potential to deliver best practice commercial-cooperative partnerships in the post-support era. A valuable insight and addition to this master project would be a detailed investigation of limited liability companies and their role in the process of enabling citizen engagement in the wind energy sector. This will contribute to the holistic picture of citizen initiatives in the energy transition.

As the German energy transition is a project that affects society in general, the found regional differences in citizen activity should be investigated in depth. An investigation of regional policy frameworks, as a governing factor for citizen-led wind power, may inform about further barriers and enablers on the regional scale. Furthermore, the key role of associations in the wind energy acceptance debate needs to be investigated in more depth, as most of the current literature on citizen-led initiatives focuses mainly on cooperatives.

Business model evolution or developments in Germany might also stimulate the interest of other European countries and their ability to recognize citizen potential in the attempt to transition the energy sector from fossil to renewable energy sources. The insights should be compared with developments in other European countries, to create a record of the current state of European citizen-led initiatives. This record is especially important, as spatial variations have the potential to create resilience and to contribute to the security of supply on the European energy market.

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